The Role of Subjective Experience in Judgments of Time

Philippa Anne Ryder

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Department of Experimental Psychology

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ABSTRACT

Previous research has shown that the subjective experience of ease or difficulty evoked by memory retrieval operations can play an important role in shaping a range of people's judgments (e.g., Schwarz, 1998). Rather than basing their outputs on the products of the retrieval process, people use experiential cues to guide response generation. Extending work of this kind, the present research investigated the extent to which experiences associated with prior processing operations (e.g., memory encoding and memory retrieval) may affect people's judgments of elapsed time. In Experiments 1-5, participants committed material to memory under encoding conditions that varied in difficulty. Estimates were then taken of the duration and subjective difficulty of the encoding task. As predicted, the subjective ease or difficulty of prior processing operations was shown to guide people's retrospective duration judgments. Specifically, judgments of elapsed time were shorter under difficult processing conditions. In Experiments 6-8, this prediction was further supported when differential demands were placed on the memory retrieval process. That is, when retrieving information was experienced as difficult rather than easy, people judged that less time had elapsed. In Experiment 9, the same experiential effects emerged when immersive virtual environment technology was used to create a more dynamic task environment. These results are considered in the context of contemporary work on retrospective temporal estimation, with particular emphasis on the role of experiential factors in social cognition.

DEDICATION AND ACKNOWLEDGEMENTS

To my partner, Paul Bartlett

- My love, my rock, my chef -

This one's for you darling.

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AUTHOR'S DECLARATION

I declare that the work in this dissertation was carried out in accordance with the Regulations of the University of Bristol. The work is original except where indicated by special reference in the text and no part of the dissertation has been submitted for any other degree.

Any views expressed in the dissertation are those of the author and in no way represent those of the University of Bristol.

The dissertation has not been presented to any other University for examination either in the United Kingdom or overseas.

Signed..... Date.29/09/03.....

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CHAPTER 1

INTRODUCTION

1.1 THE CONSTRUCTION OF HUMAN JUDGMENT: WHAT TYPE OF INFORMATION DO WE USE?

As human beings living in a complex world, we are routinely faced with the task of making decisions and judgments. Although many of our judgments about the world are stored in memory (e.g., a Porsche is a fast car), on other occasions judgments must be computed on-line. For example, a friend may ask you whether your school days were enjoyable or, more generally, whether life is going well for you at the moment. When we meet a new person for the first time, we must quickly form some kind of impression of him or her. Scenarios such as these confront us everyday of our lives. For this reason, psychologists have been intrigued to discover how our judgments of situations and people are formed. When we do not have access to a stored judgment, how is a relevant decision made? What type of information do we use to guide our judgmental outputs? This important issue lies at the very heart of social cognition research, and it enables us to learn about the underlying cognitive dynamics of human judgment. By understanding how people evaluate and construe their external social environment, we are able to more accurately predict the way in which people will behave (e.g., Fazio, 1986).

Naturally, when asked to form a judgment we retrieve relevant information from memory. Accordingly, it has long been recognised that the contents of consciousness are the critical ingredients governing a person's judgments. However, people have much "available" (Tulving & Pearlstone, 1966) information stored away in memory, but this does not mean that it can be assessed when needed. Thus, several researchers have stressed that the information which is "accessible" in memory and relevant to the question at hand to be the critical factor guiding human judgment (e.g., Higgins, 1989, 1996; Higgins & Bargh, 1987; Wyer & Srull, 1989). However, even though there might be a large amount of information that is considered relevant to a particular judgment or evaluation, we hardly ever try to recall it all. To do so would take time and effort, so instead memory search is selective. In line with this assumption, other research has demonstrated that only a small portion of the most

accessible and relevant information retrieved from memory provides the basis for people's judgments (e.g., Bodenhausen & Wyer, 1987). Thus, both lines of research have emphasised the accessible contents of memory retrieval as the important input that enters into judgment. Simply said, *what* information is brought to mind is the determining factor of people's judgments and evaluations.

1.1.1 Information Accessibility Explanation

To illustrate the role of information accessibility in judgment formation, imagine you were asked to evaluate the quality of your school life. To generate an answer, you would automatically think back to your time at school so recollections of it could be retrieved from memory. Armed with such knowledge, all the relevant information that was brought to mind would be then analysed so you could evaluate whether your time at school was truly wonderful or utterly dreadful. Obviously, different people retain and recollect very different aspects of their experiences at school, but the important point here is that the *content* of the information retrieved shapes the judgment made. In this instance, if one remembered being bullied, strict teachers, failing maths and wearing an ugly uniform, it is more than likely that your time at school would be evaluated rather unfavourably. Consequently from such a content-based perspective, a person who retrieves many negative, and few positive items of information from memory should make a more unfavourable judgment than a person who retrieves only a few negative items, but many positive ones. In this way, our judgments are based on the amount and descriptive meaning of the information that is retrieved from long-term memory.

To take another example, suppose you were asked to make a more general assessment, namely how satisfied are you with your life as a whole. According to the information accessibility hypothesis, such a judgment depends on the aspects of your life that are rendered most accessible at the time the question is posed (see Bodenhausen & Wyer, 1987; Higgins, 1989, 1996; Schwarz, 1995, for reviews). Focusing on positive aspects of your life (e.g., a successful job, a lovely husband) should result in a more positive evaluation of your overall life-satisfaction. However, this is not to say that if the question were asked again at some later time, the same judgment would be generated. A large body of research has shown that assessments of life-satisfaction can be influenced by a number of situational factors, such as the

weather, mood, and even the daily news (e.g., Schwarz & Strack, 1991). All of these influences can have a strong impact on what kind of information is rendered accessible in memory, which in turn bears on the subsequent judgments that are made.

One such contextual influence that has been frequently investigated is the effect of a preceding task on people's evaluative judgments. For example, Strack, Schwarz, and Gschneidinger (1985, Expt. 1) asked participants to write a list of either positive or negative events from their life and then they evaluated their overall happiness and satisfaction with life. By manipulating what information was brought to mind prior to the judgment being made, it was possible to determine whether people base their evaluations on the descriptive contents of memory. The results supported this prediction. Participants who were induced to focus on positive events evaluated their life more positively than participants who had to think about negative ones. Thinking about these events rendered them highly accessible in memory and thus subsequent evaluations fell in line with the content of these thoughts.

A more subtle method of increasing the cognitive accessibility of information in memory involves the order in which questions are presented in a questionnaire. For example, in a survey study carried out by Strack, Martin, and Schwarz (1988) college students were asked to report how happy they were with life and how frequently they dated. This particular question was chosen as dating was considered an important factor contributing to college students' general happiness and satisfaction with life (Emmons & Diener, 1985). When the respondents evaluated their general happiness prior to reporting their dating frequency, the correlation between these two measures was small (r = - .12). However, when the order was reversed so that they first reported how frequently they dated before evaluating their life-satisfaction, a larger correlation was observed (r = .66). Thus, by first asking college students about their dating frequency, this information was rendered highly accessible in memory and, as a result, was later used as a judgment-relevant cue for evaluating their overall happiness with life. Accordingly, individuals who dated frequently returned higher ratings of life-happiness, whereas individuals who dated infrequently provided lower ratings of life-happiness. This and other related research (e.g., Schwarz & Bless, 1992; Schwarz, Strack, & Mai, 1991) has also demonstrated these contextual

influences in decision-making. Thus, judgments will change depending on whatever information happens to be most accessible in memory when the question is posed.

In the research reviewed so far, the judgment pertains to something that is familiar, such as our time at school or our own life. Consequently, social cognition research postulates that the sole determinant of judgment is the accessible information recalled from memory. However, just as often we have to construct a judgment about something we are not familiar with. For example, we frequently have to process new information about people we have just met. For that reason, a large body of research has been developed to explain how such information is processed, stored, and retrieved (see Higgins, 1989, 1996; Martin & Clark, 1990; Schwarz, 1995; Wyer & Srull, 1989, for reviews).

According to some of this work, when we encounter a new person, our impressions of him or her carry a wide array of informational input. For example, a new work colleague has hardly spoken a word to you in the office. As this behaviour, or rather lack of it, is ambiguous, it can be interpreted in a number of different ways. Do we take it to mean that he is simply shy, boring, conscientious, unhappy, rude, or ill? In line with the other research discussed, the role of information accessibility is again highlighted, but this time in the domain of impression formation. An impression of this person is most likely constructed from whichever of these trait concepts springs to mind (i.e., the one that is most accessible when the judgment is made). There are a variety of techniques that can be used to increase the accessibility of the trait concept in memory. For example, if it has been used frequently in the past (Higgins & King, 1981), by priming the trait in a preceding task (Higgins, Rholes, & Jones, 1977), or even presenting it subliminally (Bargh & Pietromonaco, 1982). Any of these manipulations would be sufficient to increase the probability that the target person would be thought of in line with the implications of the trait concept. This research demonstrates that we form an impression of another person based on the trait concept that springs to mind at the time the judgment is required.

In summary, a clear take-home message emerges from this line of research. Namely that a wide variety of evaluative judgments are based on relevant information that is most accessible in memory. As the above examples illustrate, this information strongly influences the judgments we form about the issue under investigation,

whether it is an assessment of our school days, an evaluation of our overall happiness with life, or our impressions of other people. Thus from this information accessibility standpoint, judgment generation is a fairly uncomplicated process. Decision-relevant information that comes to mind is analysed, and is then used to guide our judgmental outputs.

1.1.2 Subjective Experience Explanation: The Availability Heuristic

Although the study of decision-making has primarily focused on retrieval-mediated processes, namely the content of thought or what comes to mind, a break from this tradition came from Tversky and Kahneman's (1973) work on the *availability heuristic*. This pioneering work was both innovative and exhilarating because it offered a new and alternative explanation for how people arrive at a judgmental decision. In so doing, these authors delved into a research area that had generally been avoided or where other psychologists had feared to tread (Clore, 1992). Rather than emphasising the contents of retrieval, they focused instead on phenomenal experience itself. What they suggested is that when a question is asked, people monitor their cognitive processes as they are thinking of an answer and pay special attention to how *easy* it is to retrieve certain items of information from memory. In this way, the focus is on *how* information comes to mind rather than on *what* information appears in consciousness. Tversky and Kahneman (1973) conducted numerous studies based on this idea, but their research focused specifically on judgments of a certain kind.

In more detail, Tversky and Kahneman's (1973) availability heuristic postulates that when individuals estimate the frequency of a category or the likelihood of an event, they use 'the ease with which relevant instances come to mind' (p. 207) as the primary basis for judgment. Reliance on this heuristic is useful for judging frequency and probability because when it is easy to bring instances of a certain category to mind, or examples of likely events, this presumably indicates that the category must be frequent and the event highly probable.

In a well-known study, Tversky and Kahneman (1973, Expt. 3) asked participants to judge whether five consonants (*k*, *l*, *n*, *r*, *v*) were more likely to occur in the first

position of an English word or in the third position. Choose one of the letters and try this task. How did you arrive at an answer?

The authors assumed that generating an answer to this question involves 'comparing the availability of the two categories, i.e., by assessing the ease with which instances of the two categories come to mind' (Tversky & Kahneman, 1973, p. 211). If you had a quick go, you will probably agree that thinking of words beginning with one of these letters is without doubt a much easier task than conjuring up examples of words containing these letters in the third position. In line with this reasoning, the results confirmed that words beginning with one of these letters were judged to be more frequent in usage than words containing these letters in the third position. This was interpreted to mean that the participants considered the ease accompanying the retrieval of example words to be a reliable indicator of frequency. After all, it seems to make sense that if it is easy to think of many examples from a class of words, then the class of words must be a frequent one. However, it is important to note that in utilising this simple inferential rule, the wrong judgment was in fact made. All the letters selected by the experimenters were actually more frequent in the third position of English words than in the first position. Thus, a manipulation of how easy it was to bring words to mind prompted participants to incorrectly estimate their frequency in the English language.

There is a large body of research that supports Tversky and Kahneman's (1973) proposition that the availability heuristic is used as the primary basis for frequency and probability judgments (see Sherman & Corty, 1984, for a review). For example, Gabrielcik and Fazio (1984) observed that participants exposed to subliminally presented words containing the letter *t* judged those words to be more frequent in usage than participants who were not primed in this way. This priming procedure enhanced the availability of those words, thereby making it easier to retrieve examples of them from memory. Similarly, Lichtenstein, Slovic, Fischhoff, Layman, and Combs (1978) observed that 80% of participants judged accidents to cause more fatalities than strokes, despite the fact that dying from a stroke is in fact more likely. The authors suggested that this misconception occurs because the media attention given to fatal accidents causes them to spring to mind easily. Thus, the availability hypothesis accounts for these results by emphasising the differential availability of these events in memory and accordingly, can explain why death by accident is

misjudged as being the more likely everyday occurrence. In combination, this research suggests that individuals consider the ease with which relevant examples come to mind as a valid and reliable source of information on which to base their judgments of frequency and probability.

1.1.2.1 The Availability Heuristic: Errors and Biases

Although it appears that people frequently employ the availability heuristic, it has already been pointed out that relying on it can lead to judgmental inaccuracy. Thus, a strong implication arises from this work. Namely, when this heuristic is utilised in forming a judgment, error and biases may follow (Tversky & Kahneman, 1973; see Sherman & Corty, 1984, for an extended review). In the Lichtenstein et al. (1978) study, reading about fatal accidents in the newspaper or hearing about them on the news renders these events more available in memory than death by stroke that does not receive as much media attention. As a direct result, participants misjudged the former cause of death as more likely. This judgment was inaccurate because participants failed to take into account that the experienced ease of retrieval could have been due to the salience and the vividness of the remembered examples, rather than the actual likelihood of death by accident.

The same errors of judgment are strikingly evident in Tversky and Kahneman's (1973, Expt. 3) research. Words beginning with a certain letter (e.g., *k*) were judged to be more frequent in usage than words containing *k* in the third position, despite the reverse being actually true. The wrong judgment was made because participants did not consider the possibility that influences other than the actual frequency of the class of words could have caused words beginning with *k* to spring to mind more easily. Some researchers have suggested that one such influence concerns the manner in which words are organised and stored in memory (e.g., Collins & Quillian, 1969; Rosch, 1978). These authors demonstrated that words appear to be assessed by their first letter, so this could be one explanation for the enhanced availability of words beginning with a certain letter. Other factors which are also unrelated to frequency can impact on how easily items of information can be brought to mind. For example, if a word is recently encountered by using priming manipulations (e.g., Gabrielcik & Fazio, 1984), or if the item is vivid, salient, or memorable in some way (e.g., Nisbett

& Ross, 1980), the availability of that information will be increased, which in turn can affect the inferences made.

Taken together this research shows that there is a major problem in utilising the availability heuristic for frequency and probability judgments. When other information is not considered, errors in the attribution process occur. It is for this reason that people can draw conclusions that are inaccurate and biased (Tversky & Kahneman, 1973). In line with this assumption, it was Clore and Parrott (1991) who pointed out that the experience of ease that serves as input for judgment is prone to misattribution. Specifically, the subjective experience of ease of retrieval is misattributed to the judgment under investigation, that is, to the frequency of a category or the probability of some event, rather than to the influence of other factors.

At this juncture, an important question readily springs to mind. If this judgmental heuristic can occasionally lead us astray, why is it used as a source of information to guide our judgments? As with all heuristic processing strategies their function is a simple one. They are employed as a way of minimising the cognitive effort necessary to arrive at an answer. In this way, heuristics can be considered as simplifying rules of thumb, or cognitive shortcuts that allow us to make decisions quickly and easily (e.g., Sherman & Corty, 1984). When a judgment has to be formed under conditions in which information is incomplete or uncertainty prevails, the availability heuristic provides a way to simplify the task at hand (Tversky & Kahneman, 1973, 1974). For example, it would be an enormous feat to recall and count all the relevant examples of a given class of words in order to estimate its frequency. Instead, it is assumed that some examples are brought to mind and the experienced ease accompanying the retrieval process provides the basis for frequency estimation.

1.2 THE ROLE OF SUBJECTIVE EXPERIENCES OR FEELING STATES

It was thirty years ago that Tversky and Kahneman's (1973) work on the availability heuristic suggested that the experience of ease evoked by the process of thinking itself provides important information to judgments of frequency and probability. However, it is only more recently that psychologists in this field have begun to take on board the revolutionary idea that the many types of phenomenal experiences

accompanying thought processes may also serve as input to judgment and decision-making in general (e.g., Clore, 1992; Clore & Parrott, 1991; Schwarz & Clore, 1996, Strack, 1992). One of the main reasons for the late foray of this type of research was highlighted by Clore (1992) who noted, 'we are better prepared to study the content of thought than the experience of thinking' (p. 133). As a result, the role of conscious experience in judgment formation was neglected for many years. However, breaking away from this more traditional content-based analysis of decision-making, a large body of recent research now suggests that subjective experiences may also play a causal role in the construction of everyday judgments. Although the role of cognitive experiences, namely, the subjective experience of ease accompanying memory processing operations is the primary concern in this chapter, the majority of research in this domain has focused on experiences that involve affect and emotion (see Schwarz, 1990; Schwarz & Clore, 1988, 1996, for more detailed discussions). It is important to draw attention to this line of research as it was primarily responsible for the renewed and growing interest in determining what kinds of subjective experiences or feeling states may provide information that is used to guide people's judgmental outputs.

1.2.1 Affective Feelings and Evaluative Judgments

Perhaps this major emphasis on affective states including happiness, sadness, anger, and fear, to name only a few, results from the fact that 'one of the most distinctive aspects of emotions is that they are felt' (Clore, 1992, p. 133). Thus, it follows logically that such feelings may deliver important information to the experiencer that can be used in judgment and decision-making. Specifically, a substantial body of research has shown that individuals use their momentary affective state as a judgment-relevant cue when making a positive or a negative evaluative judgment (see Schwarz & Clore, 1988, 1996, for reviews). When individuals think about the object of judgment they may simply ask themselves, *"How-do-I-feel-about-it?"* (Schwarz & Clore, 1988).

To investigate the impact of affective states on evaluative judgment, the basic experimental procedure involves inducing a happy or a sad mood (e.g., asking participants to write a detailed description of a happy or a sad event from their recent past) and then asking participants to report their overall happiness and satisfaction

with life. The typical finding is that under elated moods. assessments of overall satisfaction and happiness with life are more positive than under depressed moods (e.g., Schwarz & Clore, 1983; Schwarz, Strack, Kommer, & Wagner. 1987). According to this line of reasoning, these mood effects occur because when a happy mood is induced prior to the judgment task, this momentary affective state is attributed to the object of judgment, and thus evaluations of life-satisfaction are more positive as a direct result. In the same way, a sad mood elicited by the previous task is considered to be an affective reaction to the question under investigation, which results in more negative assessments of life-satisfaction being made. Note that even though the perceiver's momentary mood is actually due to the previous task, these feelings are still used as a basis for the judgment at hand. Congruent with the availability heuristic research, this of course means that assessments of life-satisfaction will be biased in predictable ways.

Although this "feelings-as-information hypothesis" (Schwarz & Clore, 1983, Wyer & Carlston, 1979) can account for these results, so too can an explanation based on information accessibility. From this perspective, a person's momentary mood can impact on what information is rendered accessible in memory. For example, retrieving positive information about a happy life event prior to the judgment task renders that information highly accessible in memory and thus subsequent evaluations would be more positive in nature (e.g., Bower, 1981). Consequently, more direct evidence was needed to show that people rely on their own feelings and not on the contents of their thoughts when evaluative judgments are constructed. If decision-makers were really using the information provided by their momentary affective state as the primary basis for judgment, then if their feelings were considered uninformative for some reason they might not be used. This issue has been extensively investigated using misattribution paradigms (see Schwarz & Clore, 1988, for a review). In a typical experiment in this area of research, some participants are led to believe that there is an external, yet plausible cause for the way they are feeling and others are given no such information.

To illustrate, imagine that the experimenter told you that the soundproof room where you were being tested might make you feel tense and depressed (e.g., Schwarz & Clore, 1983). Accordingly, you might realise that it is the strange room that is causing your unhappy mood and, as a result, your feelings would not be used as a

source of information to guide the evaluative judgment. There is no point because they carry no informative value. That is, your feelings tell you nothing about your reaction to the object of judgment, for example how satisfied you are with life as a whole. On the other hand, when your reaction to the object of judgment contradicts the impact of this external factor (i.e., you feel happy with life, despite the fact that the room should be making you feel a little depressed), your feelings transmit informative cues about how you feel about the issue under investigation and thus are used as a basis for judgment. Such discounting and augmentation effects (Kelley, 1972) have been demonstrated with much consistency in this affective domain (e.g., Keltner, Locke, & Audrain, 1993; Schwarz & Clore, 1983; Schwarz, Servay, & Kumpf, 1985; Siemer & Reisenzein, 1998).

Collectively this research provides convincing evidence that affective states convey valuable information which is used to guide a wide range of evaluative judgments. Furthermore, by using misattribution paradigms, it has been revealed that the informational cues from affective experiences are only used as a basis for judgment when they can be attributed to the object under investigation. When there is another explanation that can account for these feelings (e.g., an external factor), they are not used as input to judgment. Thus, it is the informational value of these affective feelings that is considered by the experiencer when evaluative judgments are made (see Schwarz, 1990; Schwarz & Clore, 1988, 1996, for reviews). However, it is important to point out that even though individuals may understand that it is inappropriate to use their momentary affective state when it is does not reflect how they truly feel about the object of judgment, this does not imply that relying upon affective experiences involves conscious attribution about their source (see Schwarz, 1990, for a more detailed discussion). Generally, we just assume that our experiences or feelings are a reaction to whatever we are thinking about at that moment in time.

1.2.2 Bodily Feelings and Physical Judgments

The role of subjective experiences in decision-making does not end here; other phenomenal experiences have also been investigated. As Clore (1992) pointed out 'many of the most common feelings are not affective. For example, when we say we feel hungry, tired, or dizzy, we are not referring to emotions but to bodily feelings' (p. 141). In much the same way as affective states can be used as a source of

information when positive or negative evaluative judgments are generated, these kinds of bodily feelings may also serve as relevant input when asked about one's physical state (see Schwarz & Clore, 1996, for a review). For example, when asked if you are hungry, tired, or dizzy, the bodily feeling relevant to the question at hand may be used to guide your answer. Research in this area indicates that individuals draw upon their perceived momentary arousal state as a judgment-relevant cue, unless its informational value is questioned for some reason (see Zanna & Cooper, 1976; Zillman, 1978, for reviews). Thus, this line of inquiry also provides strong evidence that subjective states play a central role in the construction of human judgment.

1.2.3 Cognitive Feelings and Cognitive Judgments

Thus far, it has been noted that affective and bodily feelings may provide us with useful information for particular judgments. However, Clore (1992) and Clore and Parrott (1991) brought attention to a third class of feelings, namely "cognitive feelings" that may also communicate an informative message to the experiencer when certain cognitive judgments have to be made. In the same way that we experience happiness and sadness, or hunger and tiredness, we can have feelings of knowing, familiarity, effort, surprise, confusion, uncertainty, boredom, or amazement, to name only a few. It is these types of cognitive experiences that provide us with information about "our state of knowledge" (Clore, 1992). Even though these self-produced "feelings associated with knowing" (Schwarz & Clore, 1996) are not affective in nature, they are still experienced everyday of our lives. Hence, they may also impact on our decisions and judgments. An understanding of their influence on decision-making is made possible by the fact that it is easy to elicit such cognitive feelings in the laboratory.

Tversky and Kahneman (1973) were the first researchers to investigate the role of one of these cognitive experiences elicited by thinking in their work on the availability heuristic. As already discussed in detail, it was postulated that the ease experienced in bringing items of information to mind serves as useful information for estimating the frequency and probability of certain events. Although the subjective experience of ease accompanying processing operations is the primary focus of this chapter and related research will be reviewed shortly, it is an appropriate time to

briefly point out some other momentary cognitive experiences that have been studied (see Clore, 1992, for a review). For example, feelings of uncertainty have been found to play a role in judgments of understanding a poem (Clore & Parrott, 1994). In a similar vein, the feeling of distraction may be used for judging if a lecture is boring (Damrad-Frye & Laird, 1989), and the feeling of expectation can serve as a basis for deciding if a cartoon is funny (Wilson, Lisle, Kraft, & Wetzel, 1989). In each instance, some type of feeling that arises from the phenomenal experience of thinking is used as relevant information for making the particular kind of judgment under investigation.

In summary, this research highlights that subjective states, specifically affective, bodily and cognitive feelings all appear to provide the experiencer with useful and valid information on which to base their evaluations and judgments. Of course, the type of subjective state has to be considered relevant to the specific judgment under investigation if it is to be utilised as a source of information (Schwarz & Clore, 1996). Affective states seem to provide input for evaluative judgments, bodily feelings may convey information for physical judgments, and cognitive feelings appear to serve as cues for cognitive judgments. With this notion firmly in mind that individuals seem to rely on the information provided by their feelings to guide a wide variety of judgments, it is important to consider when and why such feelings or subjective experiences may be used in judgment formation.

1.2.4 When and Why Do We Use Them?

The most logical place to begin this discussion is with a point that has already been made, but it will be emphasised again here. At any given moment, an individual has access to a multitude of different kinds of feelings (Hardin & Rothman, 1997). However, the information provided by a specific feeling will only be used as a basis for judgment if it is perceived as relevant to the type of judgment that has to be made (Schwarz & Clore, 1996). For example, positive or negative affect can serve as a useful source of information for making positive or negative evaluative judgments (e.g., Schwarz & Clore, 1983). On the other hand, this kind of elicited experience would not be very helpful if asked to estimate the frequency of a specific event. For this particular kind of judgment, the cognitive feeling of ease accompanying the retrieval of relevant events from memory seems to convey an informative message

(Tversky & Kahneman, 1973). That is, finding it easy to think of examples can be taken as evidence that the event must be a frequent one, otherwise it would have been more difficult to think of relevant examples. Thus, the important lesson to take away is that the subjective feeling state has to be directly related to the judgment in question.

In the majority of studies investigating which informational cues enter into judgment, participants are asked to make inferences about objects that have no associated opinions already in mind (Sherman & Corty, 1984). As a result, little information may be available to participants (Schwarz & Clore, 1996), hence they may utilise the information provided by their immediate experiences. In direct contrast, when faced with a judgmental task that is so complex that decision-makers are overloaded with relevant and available information (Schwarz & Clore, 1996), they may turn to what their feelings are telling them instead of expending considerable time and cognitive effort arriving at a decision. Furthermore, situational factors can increase the complexity level of the judgment task. For example, when a person is under time pressure or is distracted in some way, subjective experiences provide a way to simplify the task at hand (Strack, 1992). Finally, another condition in which feelings may be consulted is when decision-makers are unmotivated (Strack, 1992). For example, decision-makers might not even care about the object of judgment under investigation (Branscombe & Cohen, 1991), so they are unwilling to expend large amounts of cognitive effort generating an appropriate answer.

Any of these conditions may induce individuals to rely on a heuristic strategy for judgment based on their subjective experiences (Schwarz & Clore, 1996). Taking into consideration the three classes of subjective states discussed earlier, affective, bodily and cognitive feelings, I next discuss why such feelings may be used, and in so doing show how reliance on them can simplify judgmental tasks. Judgment-relevant cues for these three types of feelings maybe, "I'm really happy", "I'm hungry" and "It was really easy to bring those words to mind". These examples are given to show that we commonly have such feelings everyday of our lives and once they are evoked, 'they are immediately accessible to the individual. That is, we have direct introspective access to them; they can be "read" like an internal meter, and no inferences are necessary to determine their nature' (Strack, 1992, p. 257). We automatically know if we are happy or sad, hungry or full, or if we are finding a task

relatively straightforward or mentally demanding, so it makes sense that we pay attention to the informational cues they convey to us.

Furthermore, rarely do we analyse our feelings or give much thought to where they come from. Instead we simply take on board their meaning which is indicative of their informative function (Clore, 1992). Thus, as our feelings are meaningful to us, it follows logically that they may be used as a reliable and valid source of input to guide our judgmental outputs. What is more, we generally believe our feelings wholeheartedly. Hence, when they are used as a basis for judgment we are likely to be confident in our assessments, whether they are correct or not. A final reason for using subjective experiences is that they can be connected to the judgment under investigation in a simple manner (Strack, 1992). For example, if asked to evaluate your general satisfaction with life, then your affective state at that moment can provide the basis for your judgment. After all, our subjective experiences are automatically assumed to be caused by whatever occupies our thoughts at that time.

Collectively these reasons show that using subjective experiences or feelings as a basis of judgment reflects a heuristic strategy as it minimises the cognitive effort required to arrive at a decision. No time or effort is wasted as judgments are constructed in a rapid and efficient manner. Basically, when this strategy is employed simpler judgments are guaranteed. However, this raises the question of whether decision-makers are aware that they use this route to judgment. Do they consciously draw conclusions based on their experiences? It would seem not to be the case. If people did have internal access to how such judgments were formed, then this judgmental heuristic would have been discovered many years ago via the method of introspection (Strack, 1992). Therefore, it seems that the immediacy of these experiences can cause decision-makers to use them as input for judgment without conscious awareness that they have actually done so.

1.3 SUMMARY – TWO ROUTES TO JUDGMENT

At this point, it is important to draw attention back to the question raised at the very beginning of this chapter. Namely, what type of information do we use to guide our judgmental outputs? The reviewed research demonstrates that two separate lines of inquiry have emerged in an attempt to answer this important question in social

cognition. This work indicates that two different types of information are available to us. Firstly, a very large body of research has highlighted that the important basis for people's judgments is the accessible contents of memory retrieval. Simply stated, *what* information comes to mind at the time the judgment has to be made is analysed, and is then used to shape our judgments and evaluations. However, more recently, alternative lines of research have suggested that subjective experiences accompanying the process of thinking may also play a significant role in the formation of everyday judgments. Of special interest here is the proposition that experiential aspects of the retrieval process itself, namely the experience that something comes to mind easily is another type of input that enters into judgment and decision-making. In this way, *how* information comes to mind is considered to be the vital factor.

This latter explanation was first suggested by Tversky and Kahneman (1973), and as a revolutionary idea that broke away from the traditional emphasis on accessible content, it can be regarded as a milestone in the study of judgment and decision-making. As previously discussed, these researchers explored the role of ease of retrieval in the class of judgments relating to frequency and probability. Later in this chapter, more recent research that has investigated this idea will be discussed in detail. However, at this juncture, it is important to draw attention to a large body of research which has shown that the fluency of processing operations, that is, the ease with which information is processed can also serve as input to a wide range of metacognitive judgments (see Benjamin & Bjork, 1996; Jacoby & Kelley, 1987; Kelley & Jacoby, 1996a, for reviews).

Prior to this review, it is important to point out that although we instinctively believe our feelings, it has already been shown that sometimes relying upon them can mislead us. For example, participants using the subjective ease with which information can be brought to mind as a cue to guide judgments of frequency and probability were often inaccurate in their evaluations (Tversky & Kahneman, 1973). The problem was that participants failed to realise that factors other than frequency and probability (e.g., how vivid or salient the remembered examples were; Nisbett & Ross, 1980) could have caused certain items of information to be retrieved more easily from memory. Under such conditions, reliance on the availability heuristic (i.e., the subjective experience of ease of retrieval) rests on a process of

misattribution (Clore & Parrott, 1991). Judgments can easily be led astray when the impact of other information is not considered. In fact, as you will observe there are many situations in which individuals fail to recognise the true source of their momentary cognitive experiences, but nevertheless still use them as a valid basis for the judgment at hand.

1.4 FLUENCY OF PROCESSING OPERATIONS

1.4.1 Processing Fluency and Metacognitive Judgments

One such cognitive experience that appears to act as information for judgment is the feeling of familiarity that an item elicits. The subjective experience of familiarity may arise from the experienced ease of processing and thus these two kinds of experiences are very closely linked (Jacoby & Dallas, 1981). A prime example of reliance on this type of experiential information comes from the research carried out by Jacoby, Kelley, Brown, and Jasechko (1989). These authors demonstrated that the feeling of familiarity that is elicited by a name is used to judge whether the named person is famous or not. Participants were asked to read aloud a list of names and were informed that they all related to nonfamous individuals. At this point, some participants were asked to return 24-hours later for further testing, whereas others immediately completed the second part of the experiment. This involved the list of nonfamous names being presented again, in addition to some new nonfamous and famous names. The task was simply to decide whether each name in the list was that of a famous person. It is important to note that the famous names pertained to only moderately well known individuals, so that they could be recognised as famous without being able to specify exactly why this was the case. By selecting names in this way, it made it more likely that fame judgments would be based on the subjective familiarity of each name presented.

The results showed that the nonfamous names from the initial list were more often mistakenly judged as famous than the nonfamous names that were only presented in the second list. The prior presentation of the nonfamous names enhanced the fluency with which these names were processed. This in turn, elicited a feeling that these nonfamous names were familiar causing them to be incorrectly judged as famous. Moreover, after a 24-hour delay this effect of false fame was even more prominent.

Presumably, participants tested promptly after reading the initial list were more confident that the nonfamous names were not famous as they remembered being told explicitly that this was the case when they were first presented. As such, they could attribute their feelings of familiarity to the correct source, namely to seeing the nonfamous names previously. However, after a 24-hour delay, participants misattributed their feelings of familiarity to the target person actually being famous. This suggests that, over time, participants were unable to consciously identify the real cause of why a name seemed familiar (e.g., a prior presentation) and as a result relied upon a misleading source of information to guide their judgments of fame.

This research was described at length because the implications of this work at a more general level need to be highlighted before other relevant research can be discussed. As Jacoby and Kelley (1987) suggested, 'people are often unconsciously influenced by memory' (p. 314), namely by memory of their past experiences. In the fame-judgment experiment discussed above, simply by rereading a nonfamous name, the familiarity of it is unconsciously influenced and this experience makes it more likely that it will be later incorrectly judged as famous. This example nicely illustrates how the effects of a prior presentation can influence subjective experience. When individuals do not recollect that the subjective experience of familiarity or processing fluency comes from a previous presentation, they very often end up attributing it incorrectly to some other salient factor of the present task, in this instance, perceived fame. Consequently, when subjective experience is used as a basis for judgment, we can easily be misguided in the inferences we make.

To take a more relevant example as you are reading through my thesis, you will no doubt be judging the quality of my writing. One way to form such a judgment would be to rely on the information provided by your experienced ease of processing (Jacoby & Kelley, 1987). Finding it easy to follow the progression of ideas throughout my thesis would probably result in a positive evaluation being made. However, imagine (but only for a moment) that you are finding it quite difficult to follow the ideas presented. In this case, you might evaluate my work rather more negatively. However, my advice would be to reread it. In doing so, you should find that paragraphs that seemed unclear at first suddenly seem to make sense. This clarity occurs because by simply reading the thesis for a second time, the ideas within it are processed more fluently. This in turn makes it more likely that you will

judge it in a positive light. Thus, this illustration shows that rereading my thesis would unconsciously influence the subjective experience of ease of processing. Once this experience of ease is elicited, it is very difficult to ignore. The consequence being that the evaluation of the quality of my writing may be altered for the better.

A large number of demonstrations across a wide range of judgment domains confirms that the unconscious influence of past experience is widespread (Jacoby & Kelley, 1987). Feelings of familiarity or the processing fluency gained from seeing an item previously not only causes a nonfamous name to be judged as famous, but it can also instigate the belief that a statement is true. A number of researchers (e.g., Bacon, 1979; Begg, Armour, & Kerr, 1985; Hasher, Goldstein, & Toppino, 1977) have shown that when plausible statements about unknown topics are repeatedly presented, judgments of their truth increased relative to statements that had not been seen before. These illusions occur because people misattribute the familiarity of the information resulting from the statements being previously presented to the information actually being true (Begg, Anas, & Farinacci, 1992). This research suggests that when we decide if something is true, we rely upon how familiar it seems. As Clore (1992) interestingly pointed out, 'it is often observed that if one tells a lie often enough, people begin to believe it' (p. 146). Together this work shows that the subjective experience of ease of processing plays an important role in shaping people's cognitive judgments such as knowing and believing.

The following examples also illustrate that relying upon subjective experience as a source of information for judgment can be misleading. When individuals fail to take into account that fluent processing stems from a prior experience, they may instead misattribute this experienced ease to other salient factors of the current task. Witherspoon and Allan (1985) presented words on a computer at very fast rates (30- or 50-msecs) and participants were asked to judge how long each word stayed on the screen. This judgment was made by pressing one of four buttons (very short, short, long, or very long). Some of the words had been read earlier and others had not. The results showed that longer duration judgments were reported for the words that had been previously presented than for the words that had not been seen earlier. Thus, the prior experience of seeing the words increased the ease with which they were processed, but this experience of ease was not attributed to its real cause. Instead the effect of a prior presentation was misattributed to a longer presentation duration.

Evidence of similar misattribution effects can be observed in an experiment carried out by Jacoby, Allan. Collins, and Larwill (1988). Participants listened to sentences played against a background of white noise and were asked to judge the loudness of the background noise for each sentence presented. As in the experiment above, some of the sentences had been presented in an earlier part of the experiment, whereas others were completely new when the noise judgments were made. In line with the duration-judgment results, participants reported the background noise to be less loud when they heard sentences that had been previously presented compared to when they listened to new sentences. Once again, the fluency accompanying information processing was misattributed to a lower background noise level instead of to the impact of the prior presentation.

In both of these examples, the enhanced ease of processing caused by the previous presentation of a word or a sentence could not be ignored, and hence, it was used as input for the judgment in question. However, even though the information provided by this experience was taken on board, failure to identify its actual source resulted in misinterpreting the fluency to a change in the physical nature of the stimulus, namely to a longer duration or to a lower noise level. Such demonstrations clearly reveal that the past has a strong influence on our 'perception and interpretation of later events' (Jacoby & Kelley, 1987, p. 314), even though the relevant past experience is not recognised. In fact, the above authors pointed out that there seems to be little we can do to avoid memory of a previous presentation influencing subjective experience. Thus, it follows that when this experience is used as a basis for judgment, a resultant negative consequence is that judgments are left open to error because not all the information is considered. Unfortunately, the downside of this is that people's judgments are not always accurate.

Taking this one step further, Jacoby and Kelley (1987) explored whether people use their experience of processing fluency when judgments about others are made. To demonstrate, participants were asked to rate how difficult other people would find it to solve anagrams. Some had read the solution words for the anagrams from a list presented earlier in the experiment, yet for others the anagrams were new when the judgments had to be made. For those participants who had previously seen the answers, the anagram-solving task was experienced as easy – after all, they had just seen the answers. The results revealed that those participants rated the anagram task

as easier for other people compared to the group of participants who had not previously seen the solution words. In fact this was the case even though the participants were actually informed that the people they were making the judgment for would not see the solutions to the anagrams. This was taken as evidence that participants used their own experienced ease of processing as a basis for judging the difficulty of the anagrams for others. As in the other examples discussed. having recently seen the answers to the anagram problems increased how fluently the anagrams themselves were processed and this experience was then misattributed to the task being easy. As Kelley and Jacoby (1996a) note 'the ability to make accurate predictions of judgments for others is central for clear communication and smooth social interactions' (p. 291). Thus, it is a little worrying to find out that reliance on subjective experience still prevails even though it can lead to unreliable social predictions.

It is worthwhile drawing attention to a later study conducted by Kelley and Jacoby (1996b, Expt. 2). Under certain circumstances, it was found that subjective experience could be discounted as a relevant source of information for predicting the difficulty of anagram solving for other people. For this to happen, participants had to be explicitly informed that some of the anagrams would seem easy because they had previously seen the solution words and they had to be warned that this experience of processing ease should not mislead them when formulating their judgments. In addition, after solving the anagrams, recognition judgments had to be made as to whether the solution word had been presented earlier (old) or not (new). Both factors were found to be necessary to avoid a prior presentation impacting upon their judgments of how difficult other people would find the anagrams.

From this array of research, it is very clear that when processing fluency is used to guide people's judgmental outputs, inferential errors can arise. This occurs because individuals very often are unaware and lack understanding that a prior presentation of an item enhances how fluently it is processed (Jacoby & Kelley, 1987). As a result, when the item is shown again, the accompanying processing ease is misattributed to other relevant factors of the task. Naturally, the most obvious source to draw upon is whatever kind of judgment is required in the experiment. As the reviewed work demonstrates, individuals use their subjective experience of ease of processing to guide their judgments of a person's fame or the truth of a statement. It

has also been shown to influence the physical nature of events, such as judgments about duration and noise. Finally, the fluency of processing operations is even used as a relevant cue when people make judgments for other people, such as predicting the difficulty of problem solving.

Many researchers in this domain consider reliance on subjective experience to be a "nonanalytic" route to judgment formation (e.g., Jacoby 1988: Jacoby & Brooks, 1984). This is because people's judgments can be unconsciously influenced by a number of factors, some relevant for the judgment at hand, but others completely irrelevant. It has been observed throughout this discussion on processing fluency that the irrelevant influence of a prior presentation cannot be ignored when nonanalytical judgments are constructed. However, in some of the examples reviewed, individuals discounted the information provided by their subjective experience as they realised that it could be misleading (e.g., Jacoby et al., 1989: Kelley & Jacoby, 1996b). Under such circumstances, it has been suggested that people adopt a more "analytic" judgmental strategy. In this case, the real cause of fluent processing is understood and thus, memory of a previous experience does not influence subsequent judgments (e.g., Jacoby, 1988; Jacoby, Kelley, & Dywan, 1989). However, as this approach requires considerable effort, most individuals seem to opt for a judgmental strategy based on subjective experience (e.g., Jacoby, 1988). In summary, this body of research has demonstrated that processing fluency has a pervasive influence on a wide range of metacognitive judgments.

1.4.2 Retrieval Fluency and Metacognitive Judgments

In the same way that some things are more easily processed than others, we often find that some types of information can be brought to mind effortlessly, whereas recalling other information is considerably more difficult. For example, our e-mail address can be retrieved from memory very easily, but could we say the same of our friends' addresses, probably not. As such, this experienced ease of retrieval seems to tell us something about our degree of knowledge, in this instance, how well we know e-mail addresses. Although Tversky and Kahneman (1973) first explored this idea of using ease of item retrieval to guide judgments of frequency and probability, subsequent lines of research have also demonstrated that how easily something comes to mind can influence metacognitive judgments.

One such judgment that has been investigated is confidence in question answering. That is, when a question is asked and an answer comes to mind, how do we know it is correct? One possibility is that we have more confidence in our answer when we can generate much supporting evidence for it (e.g., Graesser & Hemphill, 1991; Koriat, Lichtenstein, & Fischhoff, 1980). However, it has recently been suggested that this analysis of confidence is incomplete. In line with the general theme of this chapter, an alternative explanation highlights the role of subjective experiences that accompany the retrieval process itself. Specifically, the ease with which an answer is brought to mind may also be used as a reliable basis for confidence (e.g., Costermans, Lories, & Ansay, 1992; Kelley & Lindsay, 1993; Nelson & Narens, 1990).

In a number of experiments, Kelley and Lindsay (1993) provided convincing evidence for an experience-based explanation. Participants were asked to answer a number of general knowledge questions, such as, "What was Buffalo Bill's last name?" As in the other research discussed, fluency or ease of retrieval was manipulated by having participants read a list of words before attempting to answer the questions. Some of these words were the correct answers to the questions, whereas others were plausible, but actually incorrect answers. It was assumed that this prior reading of an answer (whether it is correct or not) causes it to quickly and easily spring to mind when relevant questions are later asked. Accordingly, it was hypothesised that this ease of item retrieval may contribute to the feeling of greater confidence in the accuracy of the answer.

This is exactly what Kelley and Lindsay (1993) observed, thereby demonstrating the causal role of retrieval ease in confidence. Participants gave their answers to the general knowledge questions more quickly and reported more confidence in them when they came to mind easily. Of course, for some questions this meant that the right answer was actually given as that word had been presented earlier. However, for others an incorrect answer had been primed so illusions of knowing occurred. In another experiment, Kelley and Lindsay (1993, Expt. 2) found that even when participants were explicitly informed that some of the studied answers were correct and some were incorrect, the same pattern of results emerged.

This research clearly shows that the ease with which information comes to mind serves as an informative cue for metacognitive judgments. Benjamin and Bjork (1996) have noted that, 'clearly, it makes sense to use retrieval fluency as an indicator of what we know' (p. 321). However, it has been observed that relying upon this judgmental heuristic still prevails even though individuals are likely to suffer from illusions about their own level of knowledge – we think we know more than we actually do! By using retrieval fluency as a basis for confidence, perceivers were confident in their answers to general knowledge questions even when they were wrong. These judgmental biases occurred because individuals failed to understand that certain items of information came to mind more easily because they were presented previously in an earlier part of the experiment. A prior presentation impacts on subjective experience unconsciously, so its effects were not recognised. Thus, instead of attributing the momentary cognitive experience to its correct source, the facilitating effects of ease were misattributed to feeling confident in the answer given. After all, in an experiment nothing is more striking than the object of judgment under investigation.

1.4.3 Summary

It therefore appears that people taking part in experiments are generally motivated to simply answer the question posed or make the judgment required, rather than identifying where the answer or evaluation comes from (Jacoby, Kelley, & Dywan, 1989). A judgmental heuristic based on the fluency of processing or retrieval operations fulfils this need. Judgments can be constructed quickly and with minimal effort. Although this discussion has focused on the errors that arise from utilising this judgmental strategy, it is important to bear in mind that these biases are a consequence of experimental design. With careful planning and specific manipulations in place, it becomes very easy to mislead the participants taking part. As noted by Kelley & Jacoby (1996a), such errors 'are useful for revealing the basis for judgments' (p. 305).

In combination, this body of research has demonstrated that people use subjective experiences that accompany information processing to guide their metacognitive judgments. Such cognitive experiences provide the decision-maker with valuable information, and accordingly, seem to be used frequently in judgment formation. An

understanding of their role in shaping people's judgmental outputs is made possible by the fact that these kinds of cognitive experiences are easy to elicit in experimental situations. A common factor of all the studies described so far rests on how this was done. Some kind of priming procedure (e.g., a prior presentation) is employed as a way of directly manipulating the ease or the fluency with which an item is processed or retrieved. Priming some target item by presenting it earlier in the experiment has been found to temporarily increase its cognitive accessibility in memory (e.g., Higgins et al., 1977; Srull & Wyer, 1979). This occurs even when the item is presented in a task that seems unrelated to the later judgmental task. When this is followed by a task that cues this item in some way, it is processed or retrieved with marked facility.

It is important however, to draw attention to the fact that Tversky and Kahneman's (1973) seminal work on the availability heuristic (i.e., the subjective experience of ease of retrieval) did not employ this kind of procedure. In contrast, the subjective demands of retrieval were manipulated by selecting items for study that were presumed to be already differentially available in memory. To reiterate on one of their studies previously discussed (Tversky & Kahneman, 1973, Expt. 3), participants were asked to judge whether a certain letter (e.g., *k*) is more likely to occur in the first position of an English word or in the third position. Thus, by choosing two classes of words that were assumed to be more (words beginning with *k*) or less (words containing *k* in the third position) available in memory, retrieval ease was indirectly manipulated. In line with this assumption, participants overestimated the frequency of the former class of words relative to the latter class, even though this was in fact the wrong answer. This error in judgment occurred because it was presumably easier to think of words beginning with the letter *k* than words containing *k* in the third position. Thus, the subjective experience of ease of retrieval was emphasised as the important basis for frequency judgments.

1.5 PROBLEMS WITH THE AVAILABILITY HEURISTIC

Although Tversky and Kahneman's (1973) research has been very influential in highlighting the role of retrieval ease in judgments of frequency, likelihood, and typicality, it is important to point out a major shortcoming of this work which was emphasised by Schwarz, Bless, Strack, Klumpp, Rittenauer-Schatka, and Simons

(1991). By manipulating the differential availability of two classes of words in memory, the process of memory retrieval can be affected in two different ways. Not only can availability cause a difference in how easily examples from each class of words can be brought to mind, but also the numerical amount of information retrieved may vary as a function of this as well. When retrieving example words is experienced as easy, it could be argued that a greater number of exemplars are generated. Unfortunately, this means that an alternative explanation can also account for Tversky and Kahneman's (1973) findings. Instead of using the experienced ease evoked by memory retrieval operations as a cue to judgment, frequency estimates may have been based on the number of words actually retrieved. A judgmental strategy that relies on either type of information, that is, the *subjective experience* of ease of retrieval, or the *content* of memory retrieval would result in the same inference being made. Specifically, higher frequency estimates for words beginning with a certain letter. As this was indeed the finding observed by Tversky and Kahneman (1973, Expt. 3), Schwarz, Bless, et al. (1991) noted that it remains unclear which is the underlying process of frequency estimation.

In another of Tversky and Kahneman's studies (1973, Expt. 8), the same problem exists. Participants listened to two lists of people's names. One contained the names of 19 famous men and 20 less famous women, and the other included 19 famous women and 20 less famous men. Following this listening task, some participants were asked to judge whether the names of men or women occurred more frequently in the lists, whereas others were asked to recall as many of the names as possible. The results revealed that participants judged the gender which related to the more famous names as more frequent. As such, they believed that more men's names were presented in the first list, yet more women's names in the second. Once again, this was in error as the reverse was actually true. The authors proposed an experience-based explanation for these biased assessments. Finding it easier to bring the famous names to mind than the less famous ones led participants to infer that the gender associated with more famous names was more frequent. In the other study discussed previously (Tversky & Kahneman, 1973, Expt. 3) no retrieval task was performed, but it can be presumed that when retrieval of example words is experienced as easy, this would be accompanied by a greater number of examples being generated. However, the results of this experiment showed that indeed more famous names were actually retrieved from memory than less famous ones, in fact, nearly twice the

amount. Thus, judgments of frequency may have been based on the *ease* with which the names could be brought to mind, or on the *number* of names actually recalled. As in the previous study, using either judgmental strategy would lead to the same assessment being made. Unfortunately, this makes it all the more difficult to determine which one is used.

In fact, most of the studies supporting the availability heuristic suffer from the same complications (see Sherman & Corty, 1984; Taylor, 1982; Taylor & Thompson, 1982, for reviews). For example, Lichtenstein et al. (1978) found that death by accident was judged as more likely than death by stroke. The availability heuristic predicts that as memory is scanned for relevant cases of each cause of death, examples of fatal accidents pop to mind more easily than examples of fatal strokes. Perhaps this occurs as a result of these types of events receiving more media attention (e.g., newspapers, television). As such, the experience of ease accompanying the retrieval of such events can explain why death by accident is misjudged as more likely. However, in line with the other examples discussed, the observed results can also be explained by a judgmental strategy based on the actual products of the retrieval process. Finding it *easy* to recall examples of fatal accidents would presumably cause an increase in the *amount* of examples retrieved.

Together, these examples clearly illustrate that a major problem surrounds this research. Most of the studies bearing on the availability heuristic are left open to the alternative interpretation that the products of memory retrieval serve as the basis for judgment. Naturally, this leaves us wondering which type of information enters into judgment. Do we rely upon the subjective experience of ease of retrieval as a cue to guide our judgmental outputs, or on the descriptive contents of what we retrieve? Schwarz, Bless, et al. (1991) note that the lack of clarity on this issue stems from the fact that experimental manipulations designed to increase how easily information comes to mind can also have the effect of increasing the amount of information that comes to mind. Of course, the direct consequence of this is that it is very difficult to be certain which process is responsible for guiding people's judgments of frequency, likelihood, and typicality.

However, as the content-based explanation is the more traditional and widely accepted hypothesis, the assumed role of retrieval ease was called into question by

these ambiguities. What was needed was more conclusive research showing that the subjective experience of ease of retrieval serves as informative input to social judgment on its own – that is, completely separate from the actual information retrieved. Taylor (1982) noted that if this was not the case, the availability heuristic would be rather redundant as a theory because 'one's judgments are always based on what comes to mind' (p.199).

1.6 TWO BASES FOR JUDGMENT: CONTENT VS. SUBJECTIVE EXPERIENCE

This knotty issue was left unresolved for a while, in large part because these two bases for judgment had been explored separately in the decision-making literature. Moreover, an experimental paradigm had to be devised in which the content of retrieval and the experienced ease of retrieval would lead to opposite judgmental decisions. It was the impressive work carried out by Schwarz, Bless, et al. (1991) that managed to successfully unravel these two competing explanations of judgment formation.

To demonstrate how this was done, let us consider the scenario again where a person is asked to evaluate the quality of their time at school. Suppose that some people are asked to recall 6 positive pieces of information about their schooling and others have to recall 12 positive pieces of information. Note however, that as individuals try to remember a large number of examples, it is more than likely that they will experience some difficulty in doing so. In stark contrast, recalling a smaller number is considered to be a much easier task. After the required amount of information is brought to mind, imagine that they are all asked to evaluate the quality of their time at school. This type of retrieval task provides the decision-maker with two possible bases for judgment. That is, the actual contents of retrieval and the experienced ease or difficulty of retrieval. As you will see below, evaluations of school life would be very different depending on which type of information is utilised to guide such judgments.

A content-based explanation would predict that individuals should evaluate their time at school as more enjoyable after 12 positive pieces of information are recalled than after 6 positive examples are brought to mind. According to this hypothesis,

recalling these examples makes them highly accessible in memory, so when they are asked to make an evaluation it is the content of retrieval that serves as input to the judgment. As such, school ratings are based on the descriptive meaning of *what* comes to mind; the more positive examples retrieved, the better the evaluation.

Contrast this however with an experience-based prediction. Individuals who were given the demanding task of recalling 12 positive thoughts should judge their time at school as less enjoyable than those individuals who only had to recall 6 examples. Note that reliance on this judgment strategy causes the exact opposite evaluation to be made. According to this hypothesis, individuals who experience difficulty bringing positive examples to mind interpret it to mean that their time at school could not have been that enjoyable, otherwise it would not have been so hard to think of relevant examples. Thus, even though these individuals recalled twice as many positive thoughts about their schooling, the difficulty or effort experienced in doing so may have the interesting, but counterintuitive effect of decreasing their evaluations of how enjoyable school life actually was. In this way, school ratings are based on the informational implications of *how* easy or difficult it was to bring examples to mind; the more demanding and effortful, the worse the evaluation. In line with the other subjective states discussed earlier, relying on subjective experiences that accompany the retrieval process can bias the evaluations made. The difficulty encountered in generating many positive examples is attributed to school life being rather negative when in fact this experience is a direct consequence of task demands. However, if this is not understood, judgments can be influenced unconsciously.

As noted earlier, the way in which the subjective experience of ease of retrieval was manipulated by past research was also likely to increase the amount of information that came to mind (e.g., Tversky & Kahneman, 1973). For this reason, strong conclusions could not be drawn about the underlying process mediating judgment as both strategies would lead to the same outcomes (Schwarz, Bless, et al., 1991). However, the above example clearly illustrates that when the subjective demands of retrieval (ease or difficulty) are manipulated by varying the amount of information that has to be generated in a retrieval task (few or many examples), these problems are overcome. This method of manipulation is successful in increasing how easily information is brought to mind, but at the same time decreasing how much

information is retrieved. Consequently, reliance on each type of information leads to completely opposite judgmental decisions making it possible to determine which is driving the judgment made. It is important to bear in mind that this school example is purely hypothetical, yet considered in detail as a way of highlighting how the distinct influences of the content of retrieval and the experienced ease of retrieval can be unravelled in judgment formation. This is important to understand because several studies have tested this idea. Furthermore, this is the paradigm that inspired the current research.

1.6.1 Retrieval Experiences as Information: Self-Related Judgment

It was Schwarz, Bless, et al. (1991) who devised and first used this methodology (easy versus difficult retrieval operations) in a series of experiments. By placing the two competing explanations for judgment in opposition, it was possible to determine whether people rely on the content of retrieval or on the phenomenal experience of retrieval itself when specific judgments are furnished. In this research, people's assessment of their own assertiveness was the judgment under investigation. Schwarz, Bless, et al. (1991, Expt. 1) asked participants to provide instances of their own assertive or unassertive behaviour. In each of these conditions, half the participants recalled and wrote down 6 behavioural episodes and the other half had to do the same for 12 behavioural episodes. Pre-testing had established that it was relatively easy to come up with 6 examples, whereas it was much more difficult to bring 12 examples to mind. It is important to note that even though this latter task was experienced as more effortful and difficult, all participants could complete it. After the required number of behavioural episodes had been generated, participants were asked to evaluate their own assertiveness on a 10-point scale (the higher the value, the higher the assertiveness). Following this judgment task, participants rated how much difficulty they had experienced generating the examples. This was done using a scale 'ranging from *not at all difficult* (1) to *very difficult* (10)' and provided 'a direct measure of experienced ease of recall' (Schwarz, Bless, et al., 1991, p. 196).

There was no surprise in terms of the difficulty ratings. In line with pre-testing, participants reported that it was easier to recall 6 rather than 12 instances that typified their assertive or unassertive behaviour. However, the judgments of self-assertiveness revealed an interesting pattern. As expected, self-reports of

assertiveness were higher after 6 assertive behaviours were brought to mind rather than 6 unassertive behaviours. Thus. when retrieving examples was experienced as easy, self-judgments were in line with the descriptive meaning of the accessible information retrieved from memory. A judgment strategy based on the contents of retrieval would also predict that ratings of assertiveness should be higher following the retrieval of 12 rather than 6 assertive behaviours and lower following the retrieval of 12 rather than 6 unassertive behaviours. After all, more examples that typify that kind of behaviour are recalled from memory. However, this pattern of results did not emerge. Interestingly, the exact opposite was found.

Participants who had recalled 12 examples of assertive behaviour rated themselves as less assertive than those who had recalled 6 assertive behaviours. In a similar vein, participants inferred that they were more assertive after recalling 12 rather than 6 examples of unassertive behaviour. This was the case even though participants in the 12-example condition had recalled twice as many self-behaviours that typified high or low assertiveness. Furthermore, it was found that participants returned higher ratings of assertiveness following the retrieval of 12 unassertive behaviours rather than 12 assertive ones. Thus, when retrieving examples was experienced as difficult the trait inferences were the exact opposite to what would be expected if a content-based strategy had been utilised.

This pattern of results strongly implied that participants were not simply paying attention to the number of examples they actually generated, but instead Schwarz, Bless, et al. (1991) suggested that they reflected on the ease or difficulty with which the examples came to mind. The rationale was that participants who had to report 12 assertive (or unassertive) behaviours experienced difficulty in bringing this information to mind. Participants then translated this experience of retrieval difficulty to mean that the examples generated could not be very frequent and typical examples of their normal behaviour, otherwise it would not have been so difficult to think of behaviours that exemplified that particular trait. As a result, this prompted them to infer that they must not be very assertive (or unassertive) in everyday life.

However, it is worthwhile pointing out that Schwarz, Bless, et al. (1991) considered an alternative explanation for these findings. Even though participants were able to successfully recollect 12 instances of their own assertive or unassertive behaviour, it

was possible that they gave less persuasive examples towards the end of the task in order to complete it. As such, the items generated last may have been more accessible in memory when they judged their own assertiveness. Unfortunately, if this occurred, a content-based judgmental strategy could also account for the pattern of results found. However, a content analysis of the last two examples reported by participants revealed that they did not become less persuasive over the course of the retrieval task (Schwarz, Bless, et al., 1991, Expt. 2). In fact, to the contrary they found that the final two behavioural episodes in the 12-example condition typified the requested behaviour better than the last two examples reported in the 6-example condition. Consequently, the possibility that participants' judgments of assertiveness were based on the differential contents of retrieval was ruled out as an explanation for the results.

This analysis gave greater strength to the authors' conclusions that participants relied on their subjective experience of retrieval ease or difficulty when assessing their own assertiveness. Although this idea has to be credited to Tversky and Kahneman (1973), their work on the availability heuristic was inconclusive as the findings could also be explained by the content-based hypothesis. However, by using ingenious manipulations to disentangle these two competing explanations, Schwarz, Bless, et al. (1991) provided convincing evidence that *how* information is retrieved from memory acts as a separate judgmental process from *what* information is retrieved. Thus, in line with Tversky and Kahneman's (1973) original proposition, individuals estimate the frequency, likelihood, or typicality of an event by 'the ease with which relevant instances come to mind' (p. 207). Furthermore, this new research extended the availability heuristic by showing that not only may judgments of frequency, likelihood, and typicality increase when retrieving examples is experienced as easy, but also these judgments may decrease when it is difficult to bring examples to mind. In this way, the phenomenal experiences of ease and difficulty elicited by memory retrieval operations lie at opposite ends of a continuum and have differential effects on judgmental outcomes (Schwarz, Bless, et al., 1991).

It is important to note that even though this experimental paradigm was successful in revealing the existence and importance of retrieval experiences in decision-making, another way to provide more direct evidence is to show that sometimes it is used as a basis for judgment and at other times it is not. Schwarz, Bless, et al. (1991) did

acknowledge that this is not the only judgmental strategy that decision-makers employ. Rather, in some situations how *easily* information comes to mind may serve as a more revealing judgment-cue than the actual *content* of the information itself, yet in other situations the reverse may be true.

In related research already discussed, the informative role of affective experiences in judgment formation has been extensively investigated (see Schwarz, 1990; Schwarz & Clore, 1988, 1996, for reviews). The results from this experimental work reveal that people consider the informational value of their momentary affective state when asked to make evaluative judgments (e.g., Schwarz & Clore, 1983). It was found that people only rely on their affective experience (e.g., momentary mood) when they can attribute it (rightly or wrongly) to the judgment under investigation. However, when people are induced to misattribute the affective experience to the impact of an external factor, then it is not used as a basis for judgment. These augmentation and discounting effects (Kelley, 1972) provide a strong case that affective experiences are used to guide people's evaluative judgments. Schwarz, Bless, et al. (1991) recognised that the 'perceived diagnosticity of ease of retrieval' (p. 198) could also be varied using misattribution manipulations to determine if these cognitive experiences follow the same logic.

1.6.1.1 Questioning the Informational Value of One's Experiences

To test this idea, Schwarz, Bless, et al. (1991, Expt. 3) used the same procedure as before. Participants were asked to recall either 6 or 12 examples of their own assertive or unassertive behaviour. However, this time as participants performed the retrieval task they listened to a piece of meditation music via some headphones. Half of the participants were informed that this music would facilitate the retrieval of autobiographical memories involving assertive behavioural episodes and the other half were told that it would facilitate the retrieval of unassertive behavioural episodes.

In the conditions where participants believe that their experiences of ease or difficulty of retrieval are caused by the music, it was presumed that they would consider their accessibility experiences to be uninformative when later asked to judge their own assertiveness. For example, when retrieving 6 assertive behaviours is

experienced as easy, this manipulation would make participants think that the experience of ease tells them nothing about their true assertiveness because it simply reflects the music's influence. In the same way, finding it subjectively difficult to recall 12 assertive behaviours would not be considered very informative when participants believe that the music facilitates the retrieval of the opposite kind of behavioural episodes to those they are required to recall. After all, participants can blame their experienced difficulty on the music. In contrast, in the conditions where participants' experiences of ease or difficulty of retrieval actually contradict the effects of the music, it was presumed that their retrieval experiences would be considered very informative. For example, experiencing difficulty retrieving 12 assertive behaviours even when the music is meant to facilitate this kind of retrieval should make participants think about its informative value. That is, the experienced difficulty must tell them something about their own level of assertiveness.

Consistent with the findings observed for affective experiences, participants considered the apparent informational value of their retrieval experiences when evaluations of self-assertiveness were made. That is, they only relied on the subjective experience of ease or difficulty of bringing examples to mind when it was considered informative. As such, the results found in Experiment 1 were replicated again here. Lower ratings of assertiveness were reported after 12 assertive behaviours were recalled from memory rather than after 6 assertive behaviours. In contrast, higher ratings of assertiveness followed recall of 12 unassertive behaviours rather than after 6 unassertive behaviours. However, when participants' experiences of ease or difficulty could be explained by the influence of the music, their retrieval experiences were discounted as a basis for evaluating self-assertiveness. Participants must have realised that relying on them would be pointless because they were uninformative. As a result of this, participants turned to a content-based strategy paying attention to the number and descriptive meaning of the examples they retrieved to guide their assessments. Accordingly, trait inferences were the exact opposite to those based on subjective experience. Higher ratings of assertiveness were reported after 12 assertive behaviours were brought to mind rather than after 6 assertive behaviours, and lower ratings of assertiveness were given after 12 unassertive behaviours were recalled from memory than after 6 unassertive behaviours.

In summary, this pattern of augmentation and discounting effects (Kelley, 1972) convincingly demonstrates that the subjective experience of ease or difficulty accompanying memory retrieval can serve as a source of information for self-related judgment separately from the content of memory retrieval. Sometimes the experience of ease or difficulty is used as a basis for judgment and at other times it is not. It seems that when individuals are asked to form a judgment about their own assertiveness they pay special attention to the informational value of their retrieval experiences. Importantly, when they offer useful and informative input about their true assertiveness, an experience-based judgmental strategy is employed. However, when the experienced ease or difficulty of retrieval is uninformative because it is caused by some other factor, a content-based judgmental strategy is utilised for assessing assertiveness. Thus, the apparent diagnosticity of one's retrieval experiences seems to be an important factor governing which type of information is used for judgments of frequency, likelihood, and typicality (Schwarz, Bless, et al., 1991).

Taken together, this inspiring research by Schwarz, Bless, et al. (1991) shows that only focusing on what comes to mind is insufficient to explain how our judgments are constructed. The information provided by our experiences of ease or difficulty of retrieval also seems to play an important role. This was shown in two different ways. Firstly, it was demonstrated that reliance on each type of information can lead to different judgmental decisions. When self-relevant behaviours could be brought to mind easily, judgments reflected the content of that information. However, when self-behaviours were brought to mind with much more difficulty, judgments actually contradicted the content of the information retrieved. Secondly, it was shown that reliance on subjective experience varies as a function of its perceived informational value. Consequently, this research can be considered as a milestone in the study of decision processes. As with any new and interesting finding, especially one that enhances our understanding of the cognitive processes underlying human judgment, the natural progression was one of replication to other task domains. As the present chapter will reveal, the subjective experience of ease or difficulty of retrieval plays an influential role in shaping people's judgmental outputs across a range of domains.

Although the research by Schwarz, Bless, et al. (1991) showed these subjective ease of retrieval effects in the domain of self-related judgment, the initial demonstrations

of the availability heuristic were concerned with estimating the frequency of events that were not self-related. For example, Tversky and Kahneman (1973, Expt. 3) asked participants to estimate whether certain letters were more frequent in the first position of English words or in the third position. The results fell in line with an experience-based prediction, that is, the former class of words was judged as more frequent than the latter class. However, participants may not only have experienced greater ease in bringing words beginning with a certain letter to mind, but they may have also retrieved a larger number of these words at the time of judgment. Thus, a judgment strategy based on ease or content could explain the observed findings leaving it unclear which process served as the basis for frequency estimation (Schwarz, Bless, et al., 1991). As it was experimental work of this kind that inspired the availability heuristic in the first place, this was the most obvious domain to test whether the subjective experience of ease or difficulty of retrieval is used as a basis for judgment over and above the actual content that is retrieved.

1.6.2 Retrieval Experiences and Frequency Judgments

To explore this issue, Wänke, Schwarz, and Bless (1995) carried out a replication of Tversky and Kahneman's (1973, Expt. 3) letter-frequency experiment with some added modifications to overcome the aforementioned problems. These included keeping the number of words brought to mind constant across conditions and using misattribution manipulations to vary the perceived informational value of the experienced ease of retrieval.

The first task of this experiment involved all participants writing down ten words where the letter *t* appeared in the third position on a blank piece of paper. Participants were then asked to rate how much difficulty they had experienced completing this task. Following this, all participants were asked to write down ten words where the letter *t* appeared in the first position. Three conditions were created for recording the words generated. In the control condition a blank piece of paper was used, whereas in the two experimental conditions the sheet of paper was imprinted with rows of the letter *t* that were visible, but rather pale. In one of these experimental conditions, participants were informed that the imprinted worksheet would facilitate the retrieval of *t*-words ("facilitation condition"). In contrast, participants in the other condition were told that the imprinted worksheet would

inhibit the retrieval of *t*-words ("inhibition condition"). Both sets of instructions were expected to affect the perceived informational value of participants' experienced ease of retrieval. After listing ten *t*-words, participants then rated the difficulty of the task. Finally, all participants were asked to estimate whether the letter *t* is more frequent in the first or in the third position of a word.

In line with expectation, subjective ratings of task difficulty revealed that participants found it easier to recall ten words that contained the letter *t* in the first position than in the third position. Participants' frequency estimates followed a more complicated pattern. In the control condition, words with *t* in the first position were judged as more frequent than words with *t* in the third position; the same finding observed by Tversky and Kahneman (1973, Expt. 3). However, in the two experimental conditions, participants' frequency estimates differed as a function of the misattribution manipulations, that is, the extent to which their retrieval experiences were considered informative.

Participants in the facilitation condition who believed that the imprinted worksheet would make it easier for them to recall ten *t*-words estimated these words as less frequent in usage than those participants in the control condition who expected no such influence from their worksheet. This reflects the notion that participants realised that the experience of ease accompanying the retrieval of *t*-words was caused by the worksheet and therefore understood that using it to estimate the frequency of *t*-words would be uninformative. In this way, they attributed their experienced ease of retrieval to the worksheet's influence and as a result discounted subjective experience as a valid basis for judgment. In contrast, participants in the inhibition condition who were led to believe that the imprinted worksheet would make it difficult for them to bring ten *t*-words to mind estimated these words as more frequent in usage than those participants in the control condition. In this case, finding that *t*-words came to mind very easily, despite being told that the imprinted worksheet would inhibit recall drew participants' attention to the informative value of their experienced ease of retrieval and so used it to guide their frequency judgments.

This pattern of findings provides strong evidence that participants based their letter-frequency judgments on the subjective ease with which example words could be

brought to mind rather than on the number of words they retrieved, just as Tversky and Kahneman (1973) had suggested more than twenty years earlier. Manipulations were set in place to ensure that the amount of words recalled was always the same. Nevertheless, there were still differences in the frequency estimates made by participants in the three conditions. The only factor that was varied was the information given to participants about how the imprinted worksheet would impact on their retrieval of *t*-words. It was this manipulation that drew their attention to whether the subjective experience of ease of retrieval was informative or not, and consequently to the decision as to whether it should be used as input for judgment.

1.6.3 Retrieval Experiences and Judgments of Childhood Memory

More evidence for the informative role of retrieval experiences in decision-making comes from the work carried out by Winkielman, Schwarz, and Belli (1998). This time the judgment under investigation was the quality of one's own memory for childhood. Participants were asked to remember childhood events from the age of 5-10 years of age. To reveal experiential effects on memory judgments, some participants were asked to recall 4 childhood events (an easy task) and others had to recall 12 such events (a difficult task). Following the generation of these events, all participants were asked, "Regarding childhood memory, are there large parts of your childhood after age 5 which you can't remember?" (Winkielman et al., 1998, p. 125). The participants were given the choice of three answers: - "yes", "no", and "unsure".

The results showed that participants who had recalled 12 childhood events judged their memory as less complete than participants who had described 4 events from their childhood. In fact, it was found that 46% of participants from the 12-events condition judged that they could not remember large parts of their childhood, compared to only 19% of participants from the 4-events condition. This was the case even though the former group had recalled triple the number of events to those in the latter group. It seems that the participants who had to recall 12 events did not understand that the task was so difficult because of the high number of events they were required to recall. Consequently, when participants used their experienced difficulty of retrieval as a source of information for judgment, it had the paradoxical effect of making them infer that memory of their childhood was rather patchy. Once again, these findings suggest that judgments of childhood memory were not based on

the actual number of events brought to mind, but on the ease or difficulty that was experienced generating the childhood events. It is worth pointing out that Belli, Winkielman, Read, Schwarz, and Lynn (1998) found the same pattern of findings in this judgment domain.

Further support for the experience-based hypothesis was found in another condition of the Winkielman et al. (1998) experiment. Before participants recalled 12 childhood memories (a difficult task), they were informed that most people find this task to be a difficult one. In line with the other research discussed earlier, it was predicted that this manipulation would cause the informational value of their subjective experience of difficulty to be questioned. After all, if it is common for all people to find it difficult to bring 12 childhood events to mind, then there is nothing special if they also experience the same difficulty. With this knowledge in mind, a judgment strategy based on experienced retrieval difficulty may be discounted as a valid basis for deciding how well childhood is remembered.

Before the results are discussed, the previous findings obtained when participants were not informed about how other people would find the task need to be reiterated again here. When participants found it easy to recall 4 childhood events from memory, only 19% judged that they could not remember large parts of their childhood. This figure increased to 46% when participants experienced difficulty recalling 12 such events. However, in the additional condition where participants found it difficult to bring 12 childhood events to mind but were informed that most people suffer from the same problem, only 27% of these participants made the same memory judgment. As there was no significant difference between this condition and the 4-events condition, participants must have correctly attributed the difficulty they experienced to the high demands of the task instead of to memory being rather patchy about their childhood.

In combination, the research reviewed thus far demonstrates that judgments of self-assertiveness (Schwarz, Bless, et al., 1991), letter-frequency (Wänke et al., 1995), and childhood memory (Belli et al., 1998; Winkielman et al., 1998) are all based on the ease or difficulty with which relevant examples from these domains can be brought to mind. It was findings such as these that led Schwarz (1998) to conclude that 'the availability heuristic (Tversky & Kahneman, 1973) does indeed describe a

metacognitive judgment strategy that is based on a monitoring of one's own recall experiences' (p. 91). Furthermore, from using misattribution manipulations it is now understood that individuals do not always rely on their subjective retrieval experiences. It appears that they are only used as a basis for judgment when considered to be informative, that is, when the experience of ease or difficulty of retrieval can be attributed to the judgment under investigation. Note however, that this attribution process is sometimes in error, so the judgments based upon it can be biased and inaccurate (Tversky & Kahneman, 1973). However, under conditions where one's retrieval experiences are found to be uninformative for some reason (e.g., a situational influence), then they are discounted as a relevant source of input for judgment. As a result, the same types of judgments avoid such biasing effects (Wänke et al., 1995). Thus, an important factor governing whether the subjective experience of ease or difficulty of retrieval is used as a basis for judgment is the informational value it conveys to the experiencer; the same finding observed for affective states and bodily experiences discussed earlier (see Clore, 1992; Schwarz & Clore, 1996, for reviews). As Kelley and Jacoby (1996a) have noted, 'the importance of subjective experience is revealed by its absence as well as its presence' (p. 304).

1.6.4 Experience or Content: Perceived Self-Knowledge

In the previous studies discussed, participants were made aware that their subjective experiences accompanying the retrieval process were differentially informative by drawing their attention to some external factor that could account for their experiences of ease or difficulty. Related experimental research has shown that there are other circumstances that can also cause the experiencer to question the informational value of their retrieval experiences. Imagine for a moment that you were asked to write down the names of 12 exotic foods and that you experienced considerable difficulty in doing so. When this retrieval task is followed by a question asking you to judge the frequency of exotic foods, you are unlikely to infer that only a small number of these food types exist. That is, despite finding it difficult to think of relevant examples, you realise that this does not mean that exotic foods are rare, but rather that your own knowledge on this topic is rather limited. After all, if you are reading this, you are no doubt a Psychologist and not a Cordon Bleu Chef. In this example, the experienced difficulty of bringing exotic foods to mind is discounted as a basis for judgment because it carries no informative value. Thus, it seems that

decision-makers must believe they possess a reasonable amount of knowledge in the field in question if they are to use the information provided by their retrieval experiences (Schwarz, 1998). The research discussed below clearly demonstrates that reliance on an experience-based judgment strategy varies as a function of one's perceived knowledge in the content domain under investigation.

For example, Biller, Bless, and Schwarz (1992) asked some participants to generate 3 examples of chronic diseases and others had to recall 9 such examples. After this retrieval task was completed, participants were asked to estimate the prevalence of chronic disease in the general population. Subjective ratings of task difficulty showed that participants found it relatively easy to come up with 3 examples, whereas it was much more difficult to bring 9 such examples to mind. As for their judgments, participants believed that less people suffer from chronic diseases after they recalled 9 rather than 3 examples from memory. Thus, in line with the previous findings from other judgment domains, even though recalling 9 chronic diseases provides a broader base for the estimate, participants seemed to rely on the ease or difficulty of their retrieval experiences to guide their estimates.

To investigate whether individuals still rely on an experience-based judgment strategy when their perceived knowledge is called into question, a group of other participants were asked about their own level of knowledge on chronic diseases. This was done prior to performing the retrieval task as a way of making them consciously aware that they did not know much about the topic. This time, the exact opposite pattern of findings emerged. Participants believed that more people suffer from chronic diseases after they recalled 9 rather than 3 examples. This suggests that drawing attention to their sparse knowledge about chronic diseases caused the informational value of their retrieval experiences to be discredited. As a result, participants considered the number of examples they retrieved to be the most reliable source of information for their judgments. Similar findings have also been observed in the domain of political knowledge (Schwarz & Schuman, 1997). Together this research indicates that perceived knowledgeability is a driving factor behind whether an experience-based or content-based judgment strategy is employed. When individuals think that they know about the topic under investigation, the former type of strategy is utilised. In contrast, if very little is known about the topic, the latter type is relied upon instead.

1.6.5 Experience or Content: Level of Prejudice

In the same way that individual differences in one's level of knowledge can impact on whether retrieval experiences are used for judgment, it has been reasoned that so too can differences in a person's level of prejudice. It was the research by Dijksterhuis, Macrae, & Haddock (1999) that investigated this issue in the domain of social stereotyping. These authors predicted that when people are asked to recall gender stereotypic information from memory, its accessibility would depend on their level of prejudice towards women. That is, low-prejudiced individuals would find this task to be a difficult one, whereas high-prejudiced individuals would be unlikely to suffer from the same difficulty. Of special interest in their experiment was the much-studied question in social psychology of how people form an impression of another person, in this instance one from a stereotyped group. A large body of research has assumed that making such an evaluation is rather uncomplicated. People simply rely on the most accessible and relevant information that comes to mind at the time an impression is formed (see Higgins, 1989, 1996; Martin & Clark, 1990; Wyer & Srull, 1989, for reviews).

To determine if people may also rely on the experienced ease or difficulty of bringing that information to mind, Dijksterhuis et al. (1999) instructed low-prejudiced individuals to recall and write down stereotypic traits that differentially describe men and women. Half of these participants were asked to list 3 of these traits (an easy task) and the other half had to list 8 such traits (a difficult task). Following the generation of these items, participants were asked to form an impression of a female secretary. This occupation was chosen because it is stereotypically linked with women.

According to the content-based hypothesis, thinking of these gender stereotypic traits would render them highly accessible in memory, so the evaluation should fall in line with their stereotypic implications. In this instance, the more stereotypic traits generated, the more stereotypical the evaluation. However, this pattern of results did not emerge. Rather, participants who had recalled 8 traits from memory formed a less stereotypical impression of the female secretary than those participants who had only generated 3 traits. Presumably, finding it considerably difficult to bring 8 gender stereotypic traits to mind was considered a reliable indication that the stereotype

could not be that relevant or important for evaluating the female secretary. In contrast, experiencing ease in generating 3 traits had the reverse effect. Participants' evaluations reflected the stereotypic implications of what they retrieved. Thus, just as Schwarz, Bless, et al. (1991) demonstrated that self-assessments of assertiveness are based on the subjective experience of ease or difficulty of retrieval, it appears that so too are our evaluations of other people. Well, at least this is the case for low-prejudiced individuals who have nothing against women (Dijksterhuis et al., 1999).

When high-prejudiced individuals were tested in the same way, subjective ease of retrieval effects were not found. That is, regardless of the number of stereotypic traits generated, participants always formed a stereotypical impression of the female secretary, even more so when 8 traits were brought to mind. However, this came as no surprise when their subjective ratings of task difficulty were taken into account. Participants had reported that they found the task of recalling 8 stereotypic traits from memory to be no more difficult than recalling 3 of these traits. Although this difference in retrieval amount was enough for low-prejudiced individuals to experience ease in one condition and difficulty in the other, the same was not true for their high-prejudiced counterparts. Thus, as the subjective experience of retrieval difficulty was completely absent for these high-prejudiced individuals, they had no alterative but to base their evaluations on the contents of memory retrieval. This research interestingly highlights that reliance on an experience-based judgment strategy varies as a function of a person's level of prejudice.

1.6.6 Experiential Information: Present or Absent

In the above research by Dijksterhuis et al. (1999), it was an individual difference variable, namely a high level of prejudice that caused certain experiential information to be absent. However, another way to deprive people of this information is to make sure that they do not have access to it in the first place. It was an experiment by Wänke, Bless, and Biller (1996) that created conditions so one group of participants would experience either ease or difficulty in information retrieval, but another group would not. This first group of participants were asked to generate either supporting or opposing arguments for the use of public transportation. In each of these conditions, half the participants listed 3 arguments (an easy task) and the other half listed 7 arguments (a difficult task). Following this task, participants

were asked to rate their attitude towards public transportation. Consistent with a judgment strategy based on retrieval experiences, participants who had generated 7 supporting arguments were less in favour of public transportation than those who had generated 3 such arguments. Conversely, participants who had recalled 7 opposing arguments rated that they were more in favour of public transportation than those who had recalled 3 such arguments (other attitude-based judgments also show these ease of retrieval effects; e.g., Haddock, Rothman & Schwarz, 1996). Thus, even though this retrieval task provides decision-makers with two independent types of information, they chose to base their attitude judgments on how easily arguments came to mind rather than on what arguments were actually retrieved.

The second group of participants did not perform this retrieval task, but instead were simply asked to read the arguments provided by the first group of participants. This was followed by them rating their attitude towards public transportation, just as the first group had done. As this group of participants were only reading the arguments and not generating them, this would deprive them of any experiential information. In this condition, the exact opposite pattern of findings emerged. More positive attitudes towards public transportation were reported after participants had read 7 rather than 3 supporting arguments, and more negative attitudes were reported after they had read 7 rather than 3 opposing arguments. Given the absence of subjective experience accompanying argument retrieval, these participants had no choice but to rely on the amount and descriptive content of the arguments they read. Thus, each group of judges - the "writers" and the "readers" reported completely opposite attitudes on public transportation as they adopted different judgmental strategies (Wänke et al., 1996).

In combination, this research shows that across a wide range of task domains participants relied on the experienced ease or difficulty of retrieval to guide their judgmental outputs. This was the case unless its informational value was questioned for some reason. When participants' attention was drawn to an external factor (e.g., Schwarz, Bless, et al., 1991), to the demands of the task (e.g., Winkielman et al., 1998), or to their lack of knowledge on the topic under investigation (e.g., Biller et al., 1992), they came to realise that there was an alternative explanation that could account for their experiences of ease or difficulty. Under all of these conditions, participants discounted their retrieval experiences as a source of information and

instead relied on the content of retrieval as it provided a more reliable basis for judgment. Similarly, when no difficulty was experienced due to individual differences (Dijksterhuis et al., 1999), or experiential information was completely absent (Wänke et al., 1996), participants based their judgments on what information they brought to mind as this was the only option available to them.

Consequently, it becomes clear that the actual contents of memory retrieval and the subjective experiences accompanying the retrieval of that information both play an important role in judgment formation. In many of these experiments, researchers were in a good position to be able to predict how the decision-maker would respond to a particular question posed. After all, manipulations were set in place so that one type of information would be considered more informative than the other. However, if there was no reason to doubt either type of input and both seemed equally informative, how do decision-makers decide which judgmental strategy to utilise?

1.6.7 Experience or Content: Personal Relevance

When people are faced with a particular judgmental task, a person's level of motivation to arrive at an answer can impact on how they choose to process relevant and accessible information. A considerable amount of research in social cognition has demonstrated that people tend to rely on heuristic processing strategies when the judgment task is of low personal relevance and involvement and on more effortful systematic processing strategies when the task is of high personal relevance and involvement (Chaiken, 1987; Chaiken, Liberman, & Eagly, 1989; Eagly & Chaiken, 1993; Petty & Cacioppo, 1986). In line with Tversky and Kahneman's (1973) proposition, reliance on the ease with which information comes to mind reflects a heuristic judgmental strategy and reliance on the actual contents of the retrieval process reflects a systematic judgmental strategy. Thus, if decision-makers are differentially motivated to arrive at a particular judgment we should see differences in which source of information they draw upon.

To explore this issue, Rothman and Schwarz (1998) selected a judgment task that would be personally relevant for some participants, but not for others. In their experiment, male participants were asked to recall and write down either 3 or 8 factors (including self-behaviours and personal characteristics) that could either

increase or decrease their own risk of developing heart disease. Pre-testing had established that it was relatively easy to come up with 3 risk factors, whereas it was much more difficult to think of 8 such factors. After this retrieval task was completed, participants were asked to estimate their own risk of suffering from heart disease. As participants were recalling self-relevant information about this health issue, personal relevance was manipulated by selecting one group of male participants who had a family history of heart disease and another group who did not. It was predicted that the former group for whom the judgment task is personally relevant would be more motivated to engage in systematic processing and reflect on what information they brought to mind when constructing their risk judgments. Conversely, the authors assumed that the latter group for whom the judgment task is less personally relevant would be more likely to adopt a heuristic processing strategy and rely on their subjective retrieval experiences.

In line with these predictions, male participants with a family history of heart disease believed that they were more at risk after they had generated 8 rather than 3 risk-increasing factors and at lower risk when they had recalled 8 rather than 3 risk-decreasing factors. Thus, these participants based their judgments on the numerical amount of self-relevant information they had retrieved from memory. The exact opposite pattern of results was found for the male participants with no family history of heart disease. These participants believed that they were less at risk after they had generated 8 rather than 3 risk-increasing factors and at higher risk when they had recalled 8 rather than 3 risk-decreasing factors. In this case, judgments were based on the experienced ease or difficulty with which the self-relevant information was brought to mind. It is worthwhile pointing out that Grayson and Schwarz (1999) found the same pattern of findings when female participants were asked to assess their own risk of being sexually assaulted.

This research again shows that retrieving information from memory provides the decision-maker with two possible bases for judgment - the actual contents of memory retrieval and the subjectively experienced ease or difficulty of bringing that information to mind. An important factor governing which judgmental strategy is utilised is the individual's processing motivation at the time a judgment is required; a finding compatible with the dual-process models of judgment (e.g., Chaiken et al., 1989; Petty & Cacioppo, 1986). When the task at hand calls for a judgment that is

personally relevant to the decision-maker, a systematic processing strategy is employed and attention is paid to *what* information comes to mind. However, an unmotivated decision-maker for whom the judgment task is less personally relevant may wish to expend as little time and effort as possible. As a result, a heuristic processing strategy is adopted and the decision-maker reflects on *how* easy or difficult is was to bring the information to mind. As reliance on each of these judgment strategies can lead to completely opposite decisions being made, it is important to identify the conditions that make it more likely that decision-makers will use one source of information over the other. This research has taken us another step closer to understanding this issue. It appears that it is not only necessary to pay close attention to the situational context in which the judgment is formed, but also features of the individual need to be considered as well (Rothman & Schwarz, 1998).

1.6.8 Experience and Attitude Judgments: Level of Involvement

The above research has shown that the subjective experience of ease or difficulty of retrieval only exerts an impact on people's attitudinal judgments when the task at hand is of low personal relevance. Other recent research has also demonstrated that reliance on this type of experiential information only occurs when the individual's level of involvement with the topic of judgment is low. However, in this case, it is the extremity of a person's attitude that makes the task more or less involving. Some research already discussed bears on this issue. To reiterate, Dijksterhuis et al. (1999) found that only people who were low in prejudice towards women used their subjective experiences accompanying the retrieval of gender stereotypic information to evaluate a member of a stereotyped group, namely a female secretary. For these low-prejudiced individuals, the judgment task would have been far less involving than for individuals who were high in prejudice, and thus they were content to rely on this heuristic strategy.

Haddock, Rothman, Reber, and Schwarz (1999) also found that the extremity of a person's attitude can determine whether retrieval experiences are used as input for judgment. Individuals who were asked to assess the strength of their attitude towards doctor-assisted suicide (i.e., by making judgments of certainty, intensity, and importance) only relied on the relative ease or difficulty with which attitudinal information could be brought to mind when their pre-existing views on this issue

were not very strong. This led Dijksterhuis et al. (1999) to conclude that an experience-based judgment strategy is only used 'when people do not hold strong attitudes or beliefs about a group, a person, or an object' (p. 766). Thus, in the same way that people only rely on the subjective experience of ease or difficulty of retrieval when it is informative (e.g., Schwarz, Bless, et al., 1991), it also appears that this heuristic strategy is used when the judgmental task is not very self-relevant or involving.

However, it would be unrealistic to assume that this is always the case. Some research has shown that even when the judgment task is personally involving, for example evaluating a close friend, individuals still relied on their retrieval experiences (Rothman & Hardin, 1997, Expt. 3). These authors suggested that this occurs because in everyday life we very often form judgments of our friends based on how we *feel* about them, so the subjective feeling of ease or difficulty may have been considered a highly applicable source of information for this particular kind of judgment. In fact, it was findings like this that led Rothman and Hardin (1997) to propose that people may develop chronic habits of relying on information for judgment that they have previously used in the past.

1.7 WHAT DOES THIS MEAN? A MORE COMPLETE VIEW OF DECISION-MAKING

From reading this chapter, it should have come as no surprise to learn that there is an enormous amount of research in social cognition dedicated to enhancing our knowledge of the cognitive processes underlying human judgment. After all, decision-making is an integral and vital part of our everyday lives. The majority of research in this domain has focused on the role of the accessible contents of memory retrieval in the construction of social judgment (e.g., Higgins, 1989, 1996; Wyer & Srull, 1989). From this standpoint, people rely on the amount and descriptive meaning of the accessible information retrieved from long-term memory to guide their judgments. However, alternative lines of research have now shown that this content-based analysis of decision-making is incomplete. It seems that people also use the subjective ease or difficulty of information processing as another source of input for their judgments, evaluations, and appraisals (e.g., Clore, 1992; Jacoby & Kelley, 1987; Kelley & Jacoby, 1996a; Schwarz, 1998; Strack, 1992; Witherspoon &

Allan, 1985). Thus, it appears that social perceivers are far more sophisticated than it was originally thought when it comes to the information they use to guide their judgmental outputs.

Particular interest was paid to the recent body of research by Schwarz and his colleagues which focused specifically on subjective experiences accompanying the process of memory retrieval (e.g., Schwarz, Bless, et al., 1991). From this experience-based perspective, finding it relatively easy or considerably difficult to bring information to mind elicits a distinctive mental state which conveys useful and relevant information to the decision-maker. When one considers that this intriguing concept has only recently been embraced by social psychologists, the amount of supporting research is rather impressive. Since Schwarz, Bless, et al. (1991) first demonstrated that these subjective accessibility experiences play a prominent role in shaping judgments of self-perception, the same experiential effects have been shown across a wide range of judgment domains. For example, people seem to use their retrieval experiences to assess the quality of their own memory (Winkielman et al., 1998), their own risk of developing heart disease (Rothman & Schwarz, 1998), and to decide if their attitudes towards public transportation are favourable or not (Wänke et al., 1996).

This research undoubtedly provides a compelling case for the influential role of subjective experiences in the formation of everyday social judgments. However, the dependent variables employed in these studies pertain to subjective domains, namely to judgments that are self-related. The downside of studying such subjective judgments is that it is impossible to verify if people's judgmental outputs are accurate or inaccurate. After all, there is no correct answer or objective standard against which level of accuracy can be assessed. Thus, it is interesting to speculate whether the subjective ease or difficulty of processing operations also serves as an informative judgmental cue in more objective domains where there is a correct answer to the question posed. Clearly, such experiential effects would be even more important if they extend to judgments in objective domains. The research reported in the present thesis seeks to explore this issue.

In the literature so far, the only available evidence that subjective ease of retrieval effects are not restricted to self-related judgment concerned itself with letter-

frequency judgments (Wänke et al., 1995). However, there are a number of other domains in which subjective judgments map onto an objective reality, for example, judgments of temperature, sound, and brightness. In the same way, judgments of temporal duration (i.e., how long an event seemed to last) lend themselves to an assessment of accuracy as there is an objective standard against which these judgments can be compared (i.e., how long the event lasted in real time). Thus, as temporal duration is an interesting and readily verifiable daily human experience, it was chosen as the judgment under investigation in the present research.

1.8 TEMPORAL ESTIMATION

Two additional reasons motivate this emphasis on temporal duration. First, I wanted to select a type of judgment that plays an important role in our everyday lives. In fact, few judgments are as consequential as people's estimates of temporal duration. It is subjective estimates of this kind that enable us to interact successfully with our ever-changing external environment (Boltz, 1998; Michon, 1985). For example, without the ability to judge the passage of time, people would be unable to cross a busy road without incident, estimate the length of time a pot of tea has been brewing before pouring a cup, or gauge how long was spent studying for an examination prior to advising a friend on how best to prepare for the test. Given therefore the pivotal status of duration timing in daily life, it is surprising to learn that there has been little interest in experimental social psychology in identifying the type of information that people utilise to make estimates of time. The lack of research on this very important issue gave rise to my second reason for focusing on temporal duration judgments. Might it be the case that these objective judgments are computed in the same way that has recently been suggested for subjective judgments? That is, do people use their experienced ease or difficulty of information processing as a judgmental cue to estimate time?

Before elaborating on this assumption, it must be noted that the question of how people estimate the passage of time has long intrigued the minds of many cognitive psychologists (e.g., Block, 1979; Fraisse, 1963; Frankenhaeuser, 1959; James, 1890; Michon, 1972; Ornstein, 1969). Therefore, it is necessary to consider the way in which this topic has been investigated prior to considering the present approach to the topic. In so doing, it will become clear that the role of subjective experiences in

duration estimation has not been explored in any real systematic manner. In fact, inspection of the literature reveals that fundamental aspects of temporal cognition remain open to debate and empirical scrutiny (Block, 1990; Block & Zakay, 1997; Brown, 1997; Fraisse, 1984; Ornstein, 1969; Zakay & Block, 1997). This at least in part can be explained by the inherently elusive nature of time as a psychological construct (Michon & Jackson, 1985). As Fraisse (1984) observed, 'duration has no existence in and of itself but is the intrinsic characteristic of that which endures' (p. 2). The investigative predicament is compounded still further by the fact that no single sensory organ or processing system appears to be dedicated to the task of tracking temporal duration. Regardless of these problems confronting time researchers, there is now abundant evidence that cognitive processes mediate people's judgments of short durations in the second and minute range (e.g., Block, 1989a; Block & Zakay, 1997; Brown, 1985; Poynter, 1989; Predebon, 1996; Zakay, 1990; Zakay & Block, 1997). As Jackson (1990) so aptly put it, 'time is cognition' (p. 153).

In laboratory investigations of temporal estimation, participants are asked to process information (e.g., studying words for a subsequent memory test) or perform a task (e.g., sorting playing cards into stacks) for a given period of time usually ranging from seconds to minutes. After the experimental interval has elapsed, participants are required to estimate the duration of that interval relying solely on their subjective impressions. An important methodological distinction in this type of research is whether the duration judgment is made *prospectively* or *retrospectively* (e.g., Block, 1989a; Brown, 1985; Hicks, Miller, & Kinsbourne, 1976; Macar, Grondin, & Casini, 1994; Nichelli, 1996; Zakay, 1990; Zakay & Block, 1997).

In prospective tasks, participants are informed before the interval begins that its duration is to-be-estimated. As such, prospective temporal paradigms enable researchers to study people's awareness of passing time (Fraisse, 1984) or experienced duration (Block, 1974). In contrast, in retrospective tasks, participants only become aware that time is to-be-estimated after the critical duration has elapsed. In this way, retrospective temporal paradigms allow people's awareness of past time (Fraisse, 1984) or remembered duration (Block, 1974) to be investigated. To understand this distinction better, consider examples of prospective and retrospective timing in everyday life. When a person is waiting for an important phone call or for a

delayed train, his or her attention is drawn to the passage of time and prospective timing occurs. However, when a person is deeply engrossed in a good book, or enjoying a film, he or she pays no attention to time's passage. As such, a duration judgment can only be made retrospectively.

It is commonly accepted that different cognitive processes are responsible for prospective and retrospective duration estimation (e.g., Block, 1992; Block, George, & Reed, 1980; Grondin & Macar, 1992; Hicks, 1992; Hicks et al., 1976; McClain, 1983; Miller, Hicks, & Willette, 1978; Zakay, 1989, 1993; Zakay, Block, & Tsal, 1999; Zakay, Meran, & Ben-Shalom, 1989). In prospective tasks, as participants are fully aware that a duration judgment will be required, they presumably pay close attention to the passage of time during the experimental interval. As such, temporal information may be encoded intentionally which can then serve as the basis for their prospective duration judgments (e.g., Curton & Lordahl, 1974; Smith, 1969; Zakay, 1990, 1992). It is for this reason that models proposed to explain experienced duration emphasise attentional processes (e.g., Block & Zakay, 1996; Frankenhaeuser, 1959; Hicks, Miller, Gaes, & Bierman, 1977; Priestly, 1968; Thomas & Weaver, 1975; Zakay, 1989; Zakay & Block, 1996, 1998).

In retrospective tasks however, the problem confronting participants is that the duration to-be-estimated has already elapsed before a "temporal motive" is awakened (Doob, 1971). This of course means that participants do not pay attention to the passage of time during the critical interval. So what information do they use to form an impression of elapsed time? It is generally assumed that as participants focus their attention on the information-processing task, duration estimates of this type must be based on aspects of what is remembered of the critical interval (Block & Zakay, 1997; Frankenhaeuser, 1959; Michon, 1972). In other words, the contents of long-term memory provide information from which elapsed time can be estimated (Block, 1974; Fraisse, 1984; Zakay, 1990). Endorsing this general viewpoint, models proposed to explain the dynamics of remembered duration emphasise memory processes (e.g., Block, 1978, 1989a, 1990; Block & Reed, 1978; Fraisse, 1963; Ornstein, 1969; Poynter, 1983). These memory-based models all share the primary assumption that retrospective duration judgments are directly related to the amount of information that is processed and stored in memory during the critical interval.

Noting the distinction between these two types of duration experiences, in the present thesis I focus only on people's retrospective duration judgments. My reasoning for this emphasis on remembered duration is three-fold. First, retrospective judgments capture the manner in which the passage of time is commonly estimated in everyday life. We rarely monitor time from the onset of a specific activity or an event, yet we often estimate time after an event has elapsed (e.g., "how long did you stay at the party?", "did the film last for more than 2 hours?"). It is for this reason that Brown and Stubbs (1988) have noted that 'retrospective procedures may thus possess greater ecological validity' (p. 298). Second, this line of inquiry has received considerably less empirical attention than prospective duration estimation. As a consequence of this, the cognitive processes that may guide judgments of remembered duration remain largely unspecified. Third, the same issues addressed in the social cognition literature of how people arrive at a particular judgmental decision appear to be relevant to retrospective timing. Just as the majority of research in social cognition has emphasised the contents of memory or what comes to mind as the important input to a wide range of social judgments (e.g., Higgins, 1989; Wyer & Srull, 1989), the same has been suggested for judgments of remembered duration. Despite this similarity, one difference needs to be highlighted. Whereas the memory-based models in social cognition stress the importance of both the amount of information retrieved and the descriptive implications of that information in judgment formation, the memory-based models of retrospective timing only consider the amount of information retrieved from memory to be important. However, with new lines of research in social cognition, it has become increasingly clear that subjective experiences of ease or difficulty evoked by information processing also hold informational value for the judgmental process (e.g., Kelley & Jacoby, 1996a; Schwarz, 1998). Thus, I suspected that this kind of experiential information may also function as a useful cue when people make retrospective duration judgments.

1.8.1 Memory-Based Models of Retrospective Duration Estimation

As already noted, memory-based models are in agreement that retrospective duration judgments are constructed from the amount of information stored in memory during the critical interval. From such a content-based perspective, the more information that springs to mind at the time a duration judgment is requested, the longer duration estimates should be. Although the memory-based models overlap in terms of this

assumption, they have opposing views on the actual nature of the information that is assumed to mediate remembered duration. Inspection of the literature reveals two dominant cognitive models of retrospective duration estimation. One approach emphasises the amount of *stimulus* information stored in memory as the sole determinant of remembered duration (Ornstein, 1969), whereas the other approach emphasises the amount of *contextual* information stored in memory as the critical factor driving retrospective duration judgments (Block, 1989a; Block & Reed, 1978). These two competing models will be reviewed in turn along with some of their supporting research. Some problems and weaknesses associated with each model will also be discussed.

1.8.1.1 The Storage-Size Model

In more detail, Ornstein (1969) proposed a "storage-size" model which has turned out to be the most frequently cited explanation of how people estimate elapsed time in the second and minute range. According to this model, remembered duration is based on an assessment of the size of storage space filled with memories of the stimulus information from the critical interval. When more information is encoded during the interval or when the information is encoded in a more complex way, memory storage increases in size and as a result the remembered duration of that time period lengthens. Thus, according to this hypothesis, a person relies on the amount of stimulus information stored in memory during the target interval to compute elapsed time. The more stimulus information stored and available to be retrieved at the time of judgment, the longer the duration estimate produced.

To demonstrate that the critical determinant of retrospective time estimation is the size of memory storage of the judged interval, Ornstein (1969) conducted a number of cleverly designed experiments that measured both judgments of duration and memory of the interval's contents. In one of these experiments (Expt. VII), participants performed one of two paired-associate learning tasks. In each learning task, participants listened to the same ten words paired with either 'harsh' or 'neutral' sounds. The task was simply to learn this sound-word pairing by saying the word aloud after the relevant sound was heard. This learning task was comprised of seven trials and lasted for a period of 6 minutes. On completion of this task, all participants could correctly remember the ten words from the interval.

At this point in the experiment, some participants were dismissed, whereas others were asked to estimate the duration of the learning task. As predicted, no differences in judged duration were found between the harsh and neutral conditions as the amount of information in storage was equivalent in both conditions (that is, all participants had perfect responses on the learning task by the last trial). Importantly, pre-testing had established that words paired with harsh sounds are forgotten more quickly than the same words paired with neutral sounds. For this reason, it was expected that if the dismissed participants were unexpectedly asked to return 2 weeks later, differences in the number of words remembered from the learning task would emerge between the harsh and neutral conditions. This difference in the contents of storage should then affect the remembered duration of the learning task. In line with these predictions, participants in the harsh condition judged the duration of the learning task to be shorter than participants in the neutral condition and they remembered fewer words when retested on the paired-associate task. Thus, in both conditions and after no delay or a 2-week delay the storage-size model was supported as participants' retrospective duration judgments co-varied with the amount of information in memory storage.

In another of Ornstein's (1969) experiments (Expt. VIII), participants were asked to inspect a complex figure (an ambiguous line drawing) for 1-minute. To manipulate the way in which this information was encoded and stored in memory, one group of participants was first presented with a simplifying code that would enable them to interpret the drawing more easily, whereas a second group of participants was not given the code. Instead, these participants were shown another meaningless and complex line drawing prior to inspecting the complex test figure. It was presumed that the amount of information in memory (i.e., storage size) would be smaller for the first group of participants than for the second group because the simplifying code would allow them to store the complex figure in a more organised and efficient manner. Participants' retrospective duration judgments of the 1-minute interval filled with the complex figure and a memory measure of the amount of information in storage fell in line with the predictions of the storage-size model. That is, participants provided with a simplifying code for the complex figure judged the duration of that interval to be shorter and used fewer words to describe the figure than participants who viewed the same figure without the aid of the code.

Further support for the proposition that remembered duration is based on an assessment of the size of memory storage was obtained from testing a third group of participants. The same procedure was used as for the second group of participants but with one important difference. Immediately *after* viewing the complex figure, participants in this third group were provided with the simplifying code. These participants also judged the interval filled with the complex figure to be shorter and used fewer words to describe the figure than participants who were not provided with the code. This was interpreted to mean that these participants must have recoded the stored information about the complex figure into a simpler form and in doing so reduced the storage size of the judged interval. It is worth pointing out that Mulligan and Schiffman (1979) replicated these findings not only with ambiguous line drawings but also with verbal passages.

Thus, as the storage-size model proposes that retrospective duration judgments are based on the amount of stimulus information stored in memory from the to-be-estimated interval, a positive relationship between remembered duration and memory of the interval's contents is taken as evidence for Ornstein's (1969) hypothesis. In his experiments discussed above, the more words remembered from a paired-associate task (Expt. VII) and the more words used to describe a complex figure (Expt. VIII), the longer the duration judgment produced. Other investigators have also found evidence of this relationship using memory measures such as free-recall (e.g., Block, 1974; Frankenhaeuser, 1959; Hanley & Morris, 1982; Zakay & Feldman, 1993) and recognition (e.g., Block, 1974, 1978). However, many other investigators have failed to find that remembered duration is directly related to the amount of information recalled or recognised from the interval. Rather, duration judgments have been found to be inversely related (e.g., Underwood, 1975; Underwood & Swain, 1973) or unrelated (e.g., Block, 1974, 1978, 1986, 1992; Block & Reed, 1978; Hanley & Morris, 1982; Hicks et al., 1976; McClain, 1983; Poynter, 1983; Predebon, 1984, 1988) to these memory measures.

Taken together these findings show that the storage-size explanation of remembered duration is sometimes supported and at other times disputed. The main problem with this model is that it rests on a concept that is rather vague (e.g., Block, 1990; Predebon, 1988). Ornstein (1969) offered no precise operational definition of storage size and he even noted that 'the amount in storage can never really be measured' (p.

113). This failure to incorporate an independent way of quantifying storage size has lead researchers to test this model by measuring the amount of information that is recalled or recognised from the judged interval. It is presumed that these memory measures are positively correlated with the size of memory storage. Another problem this model encounters is that it is difficult to establish the exact nature of the cognitive processes involved when a person actually assesses the size of storage (i.e., the space filled with memories of stimulus events from the critical interval) at the time the duration judgment is made (Predebon, 1988).

1.8.1.2 The Contextual-Change Model

An alternative explanation of how people form an impression of elapsed time is offered by Block's (1978, 1989a, 1990; Block & Reed, 1978) "contextual-change" model. This model was primarily developed because Ornstein's (1969) storage-size model could not account for results that found no consistent relationship between judgments of duration in retrospect and memory for stimulus events from the judged interval. According to the contextual-change model, remembered duration is based on an assessment of the overall amount of change in cognitive context that occurred during the critical interval. These contextual changes are assumed to involve those taking place in the environmental situation (e.g., number of events, task demands) and in the person (e.g., processing strategies, emotional states). When more of these external and internal contextual changes are encoded in memory in association with the stimulus information presented in the target interval, the remembered duration of that time period lengthens. Thus, according to this view, a person relies on the amount of contextual information stored in memory during the critical interval to compute elapsed time. The more contextual changes retrieved at the time of judgment, the longer the duration estimate produced. Thus, in stark contrast to Ornstein's (1969) storage-size model, this model does not consider memory for the stimulus information that occurred during the interval to be important. Rather, memory for contextual change is emphasised.

Some research supports a contextual-change explanation of remembered duration. An experimental procedure frequently used to manipulate the amount of change experienced during the judged interval involves varying the type of levels-of-processing tasks that participants are required to perform (e.g., Block, 1992, Expt. 2;

Block & Reed, 1978, Expt. 2). These experiments have demonstrated that intervals (80-160 s) during which participants alternated between deep and shallow processing tasks were remembered as longer than those during which only one of these processing tasks was performed. This occurred even though the amount of information presented and processed was equivalent in the two conditions. The contextual-change hypothesis explains these findings by assuming that alternating between different types of levels-of-processing tasks engages the use of different cognitive processes and this causes an increase in the amount of experienced change stored in memory during the experimental duration. In this case, a difference in what they called "process context" between the mixed and unmixed processing conditions was assumed to be the particular aspect of experienced change that affected participants' retrospective duration judgments. This explanation was bolstered by the finding that no consistent relationship was found between recognition memory for the words processed during the interval and its remembered duration.

Further support for Block's (1990; Block & Reed, 1978) contextual-change model comes from a number of studies that have manipulated the amount of perceived changes by varying the degree to which the judged interval is segmented (e.g., Poynter, 1983, Expts. 1 and 2; Zakay & Feldman, 1993, Expt. 1; Zakay, Tsal, Moses, & Shahar, 1994, Expt. 1). This was done by strategically placing a specific number of high-priority events (e.g., American presidents' last names) among a list of unrelated common nouns and asking participants to memorise the list paying close attention to these high priority events. Empirical findings showed that a segmented time period (155-225 s) in which high-priority events were evenly distributed throughout the word list was judged as subjectively longer than an equivalent unsegmented time period in which the same number of high-priority events were clustered at the beginning of the word list. It was presumed that the more an interval is segmented by high-priority events, the more contextual changes are encoded and stored in memory and as a result the remembered duration of that interval lengthens (Zakay et al., 1994). This interpretation was further supported by the absence of memory performance differences between the segmented and unsegmented conditions in terms of the number of words correctly recalled or recognised.

Although the results of many studies have been interpreted as support for the hypothesis that contextual information is the prominent factor guiding people's

retrospective duration judgments (see Block, 1985, 1989b, for a comprehensive review), the contextual-change model is open to criticism. In fact, it is my opinion that this model faces even more problems than Ornstein's (1969) storage-size model. First, the concept of contextual change is vague and cognitively unspecified. In one of Block's many papers, he proposes that 'changes in process context, environmental context, emotional context, and other contextual elements, some of which may change as a function of time' (1992, p. 151) are all types of contextual change that may influence people's duration judgments. This operational definition of contextual change is far from precise; in fact to the contrary it is rather unconstrained. A second and related problem is that it is unclear which of these contextual changes are important for the duration judgment. One is not explicitly emphasised over another. Third, the contextual-change model fails to incorporate any independent way of quantifying the amount of change in cognitive context that occurred during the critical time period (Predebon, 2002). At least, measuring memory for the stimulus events from the interval may provide a direct test of the storage-size hypothesis, but no direct test has been used to support the contextual-change hypothesis. In fact, the existence of such a test is doubtful, hence the amount of change experienced during the to-be-judged interval can only be inferred from the experimental manipulations. Fourth, this lack of specificity with regard to concept and measurement means that this model is not easily refuted because it can provide post-hoc explanatory accounts for any set of results. Finally, a fifth problem with the contextual-change model is that the specific cognitive processes involved when a person assesses the overall amount of contextual change from the critical interval are unclear (Block, 1990; Predebon, 1988).

1.8.1.3 Summary

In summary, although the storage-size model and the contextual-change model vary in critical respects, they both agree that people's judgments of elapsed time are constructed from the amount of information stored in memory during the interval and retrieved at the time of judgment. If a person can remember a greater number of stimulus events (Ornstein, 1969) or contextual changes (Block, 1989a; Block & Reed, 1978) from the interval, the inference is made that more time has elapsed. Both of these models have generated a considerable amount of research and each approach has made an important contribution to the goal of understanding how people

compute elapsed time without using a clock. Nevertheless, it seems unlikely that the contents of memory (i.e., products of memory retrieval) provide the only route through which people can estimate remembered duration.

1.9 AN EXPERIENCE-BASED ACCOUNT OF RETROSPECTIVE DURATION ESTIMATION

One other possibility is that people may use their subjective experiences of ease or difficulty elicited by information processing as a cue to judge elapsed time. This assumption is based on previous research in social cognition which has shown that subjective experiences accompanying the process of memory retrieval can serve as a basis for people's judgments in a wide range of domains (e.g., Schwarz, 1998; Tversky & Kahneman, 1973). However, the retrieval process is but one stage in the information-processing sequence in which experiences of mental ease or effort can be elicited. Just as people can find it relatively easy or considerably difficult to retrieve items of information from memory (e.g., words beginning with *k* vs. words containing *k* in the third position), people can also find it easy or difficult to commit items to memory.

Imagine for example that two people are studying for the Highway Code theory test. One has a good aptitude for memorising road signs, whereas the other does not possess the same aptitude. When it comes to the test, both people pass and answer the same number of questions correctly. As such, they share a common retrieval experience as the same amount of information is remembered. However, if these people were asked how difficult they found the task of memorising the signs, each person would undoubtedly report a different encoding experience (i.e., easy and difficult respectively). This example is given as a way of illustrating how experiences associated with memory encoding can also vary in ease or difficulty independently from experiences associated with memory retrieval.

In the research carried out by Schwarz and his colleagues, participants were asked to retrieve a specified number of items of information that already resided in long-term memory (e.g., few or many self-assertive behaviours; Schwarz, Bless, et al., 1991). This experimental paradigm therefore manipulated participants' retrieval experiences (easy or difficult), but they did not have any encoding experiences. Studies of this

kind have been very informative into how information is retrieved from memory and its effects on people's judgmental outputs. However, no interest has been paid to whether people's judgments can also be affected by how easy or difficult it was for them to place information into memory in the first place. Finding it easy or difficult to commit information to memory should also elicit a distinctive experiential mental state which holds informational value for the decision-maker. Extending previous work on the role of subjective experiences in judgment formation, it is anticipated that not only may the subjective ease or difficulty of retrieval serve as a cue that guides people's retrospective duration judgments, but also the subjective ease or difficulty of encoding may function as a useful cue in this judgmental context as well. In this way, I am suggesting that it is not the memory processing operation per se that is important to the judgment, but the experience of ease or difficulty that was associated with the cognitive process.

In the research reported in this thesis, the assumption is that the experiential concomitants of prior processing operations (i.e., memory encoding and memory retrieval) may have direct implications for people's estimates of remembered duration. When remembering the temporal extent of episodes from the past, one common observation is that some events appear to pass with unusual rapidity, that is, the duration of an event is remembered as shorter than it actually was. Put another way, remembered time is underestimated relative to clock time. This frequently occurs in absorbing task contexts, such as when one is studying for an important exam the following day (encoding tasks), or when one is trying to remember the studied information in the actual exam (retrieval tasks). In settings such as these, I suspect that people may use their inferences about the subjective ease or difficulty of prior processing operations as a cue to judge elapsed time.

Specifically, when encoding or retrieving information is experienced as effortful or difficult, perceivers may feel that there was insufficient time to complete the task in a satisfactory manner (e.g., performance may feel pressurised or rushed). As a result, they will underestimate how much time was spent performing the task relative to those people who find the task of encoding or retrieving information to be much easier. Thus I am suggesting that individuals may perceive their experienced processing difficulty as relevant information for their retrospective duration judgments, at least in certain task contexts. The benefits of such an experience-based

judgmental strategy are obvious. Rather than basing duration estimates on the result of an exhaustive search of memory, people can use their experienced ease or difficulty of prior processing operations to furnish these judgments in a rapid and efficient manner. Relying on subjective experience as a basis for judgment reflects a heuristic strategy as it minimises the cognitive effort required to arrive at a decision.

1.9.1 Processing Difficulty and Retrospective Duration Judgments

To clarify the previous point, the experience-based hypothesis predicts an inverse relationship between processing difficulty and retrospective duration judgments, such that judgments of remembered duration should decrease as processing operations increase in subjective difficulty. However, it is important to point out that there are huge inconsistencies in the retrospective timing literature as to whether or not processing difficulty influences people's judgments of elapsed time (Block & Zakay, 1997). In this research, any existing relationship between these two variables is investigated by manipulating the level of information processing load during the target interval and observing its effects on the magnitude of people's duration judgments.

Although it has been found that increasing the number of stimulus events presented during the interval lengthens judgments of remembered duration (Block, 1974, E1; McClain, 1983; Predebon, 1988, 1996, E1 and 2), other manipulations of processing load have produced rather mixed results. Only a handful of manipulations have been used which include varying the complexity of a visual stimulus (more vs. less interior angles), varying the arrangement of a sequence of stimulus events (randomised vs. blocked ordering), varying the level of processing required (deep vs. shallow), or varying the level of attention required to perform the task (more vs. less concentration). Research of this kind has found that as the difficulty of the task increases, retrospective duration judgments *increase* (Block, 1974, E2, 1978, E2; Hanley & Morris, 1982, E1; McClain, 1983; Ornstein, 1969; Underwood, 1975; Underwood & Swain, 1973; Vroon, 1970, E1; Zakay, 1993), *decrease* (Brown 1985; Brown & Stubbs, 1992; Bueno Martinez, 1992; Hanley & Morris, 1982, E2; Vroon, 1970, E2; Zakay & Fallach, 1984, E3; Zakay, 1989, E1) or are *unaffected* by the particular manipulation (Block, 1992, E1; Block & Reed, 1978, E1; Gray, 1982; Hicks et al., 1976; McClain, 1983; Predebon, 1984, E1 and 2).

This failure to find any consistent relationship between processing difficulty and judgments of duration in retrospect has led researchers to believe that there is another more important mediating factor that guides people's judgments. Namely, the amount of stimulus information (Ornstein, 1969) or contextual information (e.g., Block, 1989a; Block & Reed, 1978) that is remembered from the critical time period. However, in deriving this conclusion, researchers seemed to have overlooked the possibility that this failure to find a consistent relationship between processing difficulty and retrospective duration judgments might be an artifact of experimental design. In all the experiments above, the difficulty of the information processing task was artificially manipulated by the experimenter. It is likely, however, that some conditions set up actually fail to induce the proposed difficulty differences for the participants performing the tasks. What the experimenter believes to be an easy or a difficult task may not be perceived as so by the participant.

Take for example one manipulation of processing difficulty commonly used in retrospective temporal tasks (e.g., Block, 1992, Expt. 1; Block & Reed, 1978, Expt. 1; McClain, 1983). The interval to be judged is filled with a levels-of-processing task. In such tasks referred to as 'easy' in the literature, participants are required to process the words presented at a shallow, structural level (e.g., simply reading the words or counting the number of words typed in a particular style, such as uppercase). In contrast, so called 'difficult' tasks require the presented words to be processed at a deep, semantic level (e.g., generating an action associated with the presented word, such as drink for beer, or counting the number of words from a particular category, such as animals). Experiments of this type have shown that time periods spent performing one of these easy tasks were judged to be equal in duration to those spent performing one of these more difficult tasks. Although, this is taken as evidence that information processing difficulty does not influence assessments of remembered duration, is it really the case that participants perceive these tasks as easy and difficult respectively? In fact, perfect scores were obtained in counting the number of words presented and generating an action associated with the presented word. Perhaps then, no perceived difficulty on the part of the participants can explain the lack of differences in judged duration between the two experimental conditions.

To overcome this problem, participants should simply be asked to provide a subjective rating of the task's difficulty. However, to my knowledge, this has only

been done in one experiment (Zakay & Fallach, 1984, Expt. 3). In this study, one of two versions of the Stroop colour-word test was performed during the to-be-estimated interval. One task involved reading the name of the colour-word presented (W task), whereas as the other involved naming the colour of the ink in which the colour-word was written (CW task). Although the objective difficulty of Stroop tasks is well-established, ratings of subjective difficulty also established that the CW task was perceived as more difficult than the W task. Interestingly, participants judged the duration of the difficult CW task to be shorter than that of the easy W task. Thus, retrospective duration judgments decreased as the perceived difficulty of the task increased. This suggests that when the difficulty of a task is validated by subjective difficulty ratings, more meaningful and consistent results may emerge. The ease or difficulty experienced whilst performing an information processing task may well turn out to be an important judgmental cue for inferring how much time has elapsed during the task.

1.10 THE CURRENT RESEARCH

1.10.1 Objectives

The primary objective of the present research is to investigate the extent to which the subjective ease or difficulty of prior processing operations (i.e., memory encoding and memory retrieval) influences people's retrospective duration judgments. That is, will people use their experiences of how easy or difficult it was for them to place items of information into memory as a cue to judge how much time has elapsed during a task? Similarly, will people consider the ease or difficulty they experienced bringing information to mind as a relevant and reliable basis for their duration judgments? By undertaking work of this kind, the current research is designed to confirm and extend earlier work on subjective experiences to a type of judgment not previously studied (e.g., Schwarz, 1998). These notions will be empirically tested in the following nine experiments by comparing people's retrospective duration judgments after they have performed an easy or difficult encoding task (Expts. 1-5 and 9) or an easy or difficult retrieval task (Expts. 6-8). The assumption is that if people draw on their prior processing experiences as a basis for judgment, then duration judgments should decrease as processing operations are perceived to increase in difficulty. Supporting evidence for these experiential effects would add

uniquely to the previous literature on subjective experiences and demonstrate the usefulness of this experience-based approach in a new domain, namely in retrospective duration estimation.

The second objective of the present research is to compare the predictions of the experience-based hypothesis against those derived from the traditional memory-based models of remembered duration. Ornstein's (1969) storage-size hypothesis predicts that retrospective duration judgments increase as a function of the amount of stimulus information stored in memory during the task interval. In contrast, Block's (1989a; Block & Reed, 1978) contextual-change hypothesis predicts that retrospective duration judgments increase with the amount of contextual change that is stored in memory during the critical time period. To test the predictive utility of these two hypotheses, the relationship between remembered duration and memory for events from the task interval will be examined (Expts. 1-9), as will the relationship between remembered duration and the number of contextual changes that took place during the critical time period (Expts. 7-8). The third and final objective of the current research is to investigate whether experiential effects on judgments of elapsed time can be elicited in more naturalistic task contexts (Expt. 9).

1.10.2 Overview of Experimental Procedure

In all nine experiments reported in this thesis, participants were required to perform either an easy or a difficult information-processing task for a fixed period of time. In this way, the demands placed on the process of memory encoding (Expts. 1-5 and Expt. 9) or memory retrieval (Expts. 6-8) were varied. Following the information-processing task, participants performed a distractor activity for 5 minutes and then were asked to answer two questions. One question required participants to estimate how much time they believed had elapsed during the task. The other required participants to rate how much difficulty they had experienced performing the task. This question provided a direct measure of participants' experienced ease or difficulty of encoding or retrieval and thus served as a manipulation check for the assumed differences in task difficulty between the two experimental conditions. On completion of these questions, participants were finally given either a free recall test (Expts. 1-3 and 6-8) or a recognition test (Expts. 4-5 and 9) to assess their memory for the items they had previously encoded or retrieved during the critical interval.

1.10.3 Methodological Issues

In previous retrospective temporal estimation research, the duration of the interval to be judged has ranged from about 45 s to several minutes. Thus, for the present research to be comparable, the same range was used. The shortest duration studied was 46 s and the longest was 4 min 47 s. By using a wide range of objective clock time durations, there is more scope for testing the experience-based hypothesis of remembered duration and the other two competing hypotheses. In addition, the generality of the findings across different durations can be examined. Retrospective duration judgments were made along a horizontal interval scale either via a circled response (Expts. 1-5) or by making a mark on the line (Expts. 6-9).

Of critical importance to the rationale of the present research is that participants acquire the "temporal motive" (Doob, 1971) only when they are unexpectedly given the duration judgment instructions after the task interval has elapsed. After all, this research is solely interested in how people estimate the duration of a task in retrospect. If participants were aware that time is being studied, then they would undoubtedly pay attention to the passage of time during the critical interval (i.e., concentrate on time-keeping in some way) and their subsequent duration judgment would be prospective rather than retrospective in nature. Thus, as far as the participants were concerned their only task was to perform some kind of information processing activity.

However, regardless of explicit instructions, the inquisitive mind of a person taking part in an experiment makes it likely that he or she will still speculate about the experimenter's hypotheses. In some retrospective timing studies, experimenters find a convenient way to get participants to remove their watches without arousing suspicion as to the prime purpose of the experiment. For example, McClain (1983) asked participants 'to remove their watches and jewelry because these metal objects sometimes interfere with our electronic recording equipment' (p. 186). However, instructions of this kind may actually cause participants to suspect that the experiment is related to time measurement in some way (Block & Zakay, 1997; Zakay, 1990). Therefore, to be overly cautious, no such instructions were given. Also, to be certain that duration judgments were actually formed in retrospect, participants were probed for suspicion at the end of the experiment. They were asked

what they thought the experiment was about and whether they had suspected that a duration judgment would be required. Participants were also asked not to discuss the time aspect of the experiment with any of their colleagues. Furthermore, rigorous checks were carried out to ensure that an individual who signed up for one of the following experiments had not participated in any of the previous studies.

CHAPTER 2

EXPERIMENTS 1-3

2.1 INTRODUCTION

Previous research in social cognition has shown that the subjective experience of ease or difficulty evoked by memory retrieval operations can play an influential role in shaping people's judgments (e.g., Schwarz, Bless, et al., 1991; Wänke et al., 1996; Winkielman et al., 1998). In these studies the judgments under investigation pertained to subjective domains, namely to judgments that were self-related. With judgments of this kind, the inference made is neither right nor wrong as there is no objective standard against which level of accuracy can be assessed. The question remains, therefore, of whether these experiential effects would emerge for a judgment more objective in nature where there is a correct answer to the question posed; specifically, people's retrospective duration estimates of a given task. In addition to studying a new type of judgment, the research in this chapter also extends earlier work in this domain by considering whether experiences of ease or difficulty evoked by memory encoding operations may also affect people's judgments of remembered duration.

The following three experiments will investigate the extent to which the experiential concomitants of the encoding process may influence people's retrospective duration judgments. That is, will people use their inferences about how easy or difficult it was for them to commit items of information to memory as a cue to compute how much time has elapsed during a task? This experience-based hypothesis will be competitively compared against Ornstein's (1969) storage-size hypothesis of remembered duration. According to this hypothesis, people base their retrospective duration judgments on the amount of stimulus information stored in memory (i.e., storage size) during the critical task interval. This hypothesis therefore predicts a positive relationship between remembered duration and memory for stimulus events that occurred during the task interval. Any pattern of differences or equivalences in memory measures (such as recall or recognition) should be paralleled by a similar pattern in people's retrospective duration judgments. Thus, to test Ornstein's (1969)

storage-size hypothesis, a free recall test will be administered in the three experiments to assess people's memory for the events occurring during the interval.

2.2 EXPERIMENT 1: HIGH- vs. LOW-FREQUENCY WORDS

To investigate the moderating role of prior encoding experiences on judgments of remembered duration, it is essential that participants perform a task during the to-be-judged interval that places differential demands on the memory encoding process (i.e., easy or difficult). Unlike the research carried out by Schwarz and his colleagues (e.g., Schwarz, 1998), the amount of material in mind will not be manipulated. In the present context, as the storage-size model emphasises the contents of memory as the sole determinant of retrospective timing, it is imperative that the amount of information to-be-encoded during the critical interval is held constant across the two experimental conditions. Thus, the current experiment will manipulate the difficulty of encoding operations that are undertaken on a fixed number of items. This will be achieved by requesting participants to memorise a list of either high- or low-frequency words (e.g., Gregg, 1976). It was anticipated that the lexical status of the words (high- vs. low-frequency) would moderate the encoding experience (easy vs. difficult respectively).

As long as this word frequency manipulation is successful in eliciting different encoding experiences for participants in the two experimental conditions, the experience-based experimental hypothesis predicts the following. If people use their prior encoding experiences to compute elapsed time, then judgments of remembered duration should decrease as the perceived difficulty of encoding operations increase. That is, when the encoding task is perceived to be difficult or demanding (i.e., low-frequency words), people will report that less time was available to commit the words to memory compared to when the encoding task is perceived to be relatively easy (i.e., high-frequency words). The content-based hypothesis (i.e., Ornstein's (1969) storage-size model) predicts that if people draw on the numerical amount of stimulus information stored in memory to compute elapsed time, then retrospective duration judgments should closely parallel the amount of information remembered from the task. That is, if the encoding task leads to increased, decreased, or equivalent memory for the presented words compared with the other task, people will

report that more, less, or the same amount of time was available to commit these items to memory.

2.2.1 Method

Participants and Design

Thirty female undergraduates from the University of Bristol participated in the experiment in partial fulfilment of a course requirement. The study had a single factor (word frequency: high or low) between-subjects design. Participants were randomly assigned to one of the experimental conditions.

Stimulus Materials

Two word lists were prepared. One list contained 20 high-frequency words (e.g., *number*, *second*, *doctor*; see Appendix 1) and the other list contained 20 low-frequency words (e.g., *accost*, *dispel*, *forego*; see Appendix 1). The words were selected from Francis and Kucera's (1982) word pool with occurrences over 300 per million for high-frequency words and between 0-12 occurrences per million for low-frequency words. The words were presented in a single vertical column on a sheet of paper and were typed in lowercase letters (Times New Roman font, 12 point).

Procedure

Participants were tested individually and informed that the purpose of the experiment was to investigate human memory. One of the two 20-item word lists was placed face down on the table in front of the participants. They were instructed to carefully study and memorise the words on the sheet of paper as their memory for these items would later be tested. When the experimenter said "start", participants turned over the sheet of paper and began the memorisation task. No information was given regarding the length of the study phase, but after a 90 s interval had elapsed (which was surreptitiously timed using a stopwatch), the experimenter said "stop" and the list was removed. By using these signals, the task interval (i.e., to-be-assessed duration) was delimited for the participants. Following the encoding task, participants performed a 5 min distractor activity in which they were required to describe their most recent holiday. The interval was precisely timed using a concealed stopwatch. The experimenter encouraged the participants to talk for the

full 5 min period by asking appropriate questions to prompt their recollections. This filler task was carried out to clear short-term memory and again. participants were unaware of how much time had elapsed.

The next task involved completing a questionnaire consisting of two questions that related to the memory task. The order of presentation of the questions was counterbalanced across the two experimental conditions. One question required the participants to estimate how much time they believed had elapsed during the memory task. All participants were reminded that the task interval (i.e., to-be-assessed duration) was delimited by the words 'start' and 'stop'. Below this question was a 9-point scale ranging from 70-110 s with 5 s intervals between each point. Participants were asked to circle the point that most accurately captured the duration of the word-memory task. The other question asked participants to rate how much difficulty they had experienced memorising the words. Ratings were made on a 9-point scale ranging from 1 ('*very easy*') to 9 ('*very difficult*'). Finally, participants were given a free recall task in which they were asked to bring to mind and write down as many words as possible from the initial study list in the space provided on the questionnaire. Participants were told that they could take as much time as they required, but no participant took any longer than five minutes. All participants were then debriefed as to the real purpose of the experiment, thanked for their assistance, and dismissed. None of the participants had guessed that a retrospective duration judgment would be required as they all believed that the main purpose of the experiment was to investigate their memory for the presented words.

2.2.2 Results and Discussion

Perceived Task Difficulty

To ensure that the memory task was accompanied by different encoding experiences, participants' difficulty ratings were submitted to a single factor (word frequency: high or low) between-subjects analysis of variance (ANOVA). In line with expectation, this revealed an effect of word frequency on participants' perceptions of task difficulty, $F(1,28) = 4.32$, $p < .05$. Participants considered the memory task to be less demanding when the to-be-remembered items were high- rather than low-frequency words (see Table 1 for treatment means).

Duration Estimates

A single factor (word frequency: high or low) between-subjects ANOVA was undertaken on the data. As expected, this revealed an effect of word frequency on participants' duration judgments, such that more time was believed to have been available to memorise the high- rather than the low-frequency words, $F(1,28) = 5.77$, $p < .05$ (see Table 1 for treatment means). As participants' estimates of elapsed time varied as a function of their experienced ease or difficulty of encoding, this result provides initial support for the experimental prediction.

Free Recall Performance

Free recall performance (total number of words correctly recalled) was computed for each participant as a proportion. The resultant proportional recall scores were submitted to a single factor (word frequency: high or low) between-subjects ANOVA. This analysis revealed no effect of word frequency on recall performance, $F(1,28) < 1$, *ns* (see Table 1 for treatment means). This suggests that participants who memorised the low-frequency (i.e., difficult to encode) words must have expended greater effort on the task for memory to be equivalent to those participants who memorised the high-frequency (i.e., easy to encode) words.

Table 1.

Mean Ratings of Duration (s), Task Difficulty, and Free Recall Performance as a Function of Word Frequency (standard deviations in parentheses)

Word Frequency	Duration Estimates	Task Difficulty	Free Recall
High-frequency	86.3 (7.90)	6.33 (1.59)	.373 (.11)
Low-frequency	76.6 (8.99)	7.27 (0.70)	.357 (.08)

Interestingly, Ornstein's (1969) storage-size hypothesis cannot explain the effect of word frequency on participants' retrospective duration judgments. Both the high- and low-frequency word memory tasks produced equivalent recall performance, but were not judged as equal in remembered duration. Rather, the memory task with low-frequency words was judged as shorter in retrospect than the same task with high-

frequency words. Therefore in line with the experimental predictions, the lexical status of the words was sufficient to elicit different encoding experiences and this experience of ease or difficulty then influenced the subsequent judgment. When the encoding task was deemed to be subjectively difficult or demanding (i.e., low-frequency words), participants believed that less time had been available to commit the items to memory compared to when the encoding task was deemed to be less demanding (i.e., high-frequency words).

Duration Estimates and Difficulty Ratings

Corroborating the relationship between these variables, participants' duration estimates and ratings of encoding difficulty were correlated, such that duration estimates decreased as encoding operations were perceived to increase in difficulty, $r(28) = -.471$, $p < .005$. To investigate whether the subjective difficulty of encoding operations mediated the effect of word frequency on participants' duration estimates, a mediational analysis was conducted using an analysis of covariance (ANCOVA). Three relationships between the target variables must be demonstrated in order to establish a basis for testing mediation (Baron & Kenny, 1986). The independent variable must influence both the dependent and the mediator variable and the mediator and dependent variable must be associated. Mediation is established if the effect of the independent variable (i.e., word frequency) is reduced or eliminated when the effect of the hypothesised mediating variable is taken into account. As the reported effects satisfied the conditions for testing for mediation, an ANCOVA was performed on the data. This revealed that when the subjective difficulty of the memory task was partialled out of the analysis, the effect of word frequency on duration estimates was eliminated, $F(1,27) < 1$, *ns*. This finding confirms that the subjective ease or difficulty of prior encoding operations mediated participants' judgments of remembered duration.

The results of Experiment 1 lend preliminary support to the experimental predictions. As expected, duration estimates diminished as participants perceived the task to increase in difficulty. This confirms that retrospective duration judgments were driven by the experiential concomitants (i.e., experiences of ease or difficulty) of a standard memory task. Corroborating the work of Schwarz and his colleagues (Schwarz, 1998), this finding substantiates the notion that subjective processing experiences can function as a highly informative judgmental cue - in the present

context, a cue to judge elapsed time. In demonstrating this, the present study extends previous research of this kind in two important ways. Firstly, it reveals that these experiential influences emerge not only for judgments in subjective domains (e.g., Rothman & Schwarz, 1998), but also for a judgment that is more objective in nature. Secondly, unlike other research in this domain, participants' temporal outputs were not moderated by the apparent ease or difficulty of the retrieval process (e.g., Schwarz, Bless, et al., 1991). In each of the experimental conditions, recall performance was equivalent. Participants must therefore have shared a common retrieval experience as the same amount of information was remembered from the memory task. Hence, the current results are amenable to an interpretation based on experiences of ease of difficulty associated with the encoding of to-be-remembered information. The results of the mediational analysis lend further support to this viewpoint.

Theoretically, these initial findings present problems for a content-based explanation of remembered duration (Ornstein, 1969). The expected positive relationship between retrospective duration judgments and memory for the encoded words was not found. There were large differences in remembered duration between the high- and low-frequency word memory tasks, whilst recall performance for these items was equivalent. Thus, the inference can be made that duration judgments were not based on the amount of information stored in memory. As these judgments were influenced by the nature of to-be-encoded words in the absence of memory differences, the experience-based account of remembered duration is needed to explain the current results. Duration judgments were based on an assessment of how easy or difficult it was to encode the presented words.

2.3 EXPERIMENT 2: TYPED vs. HANDWRITTEN WORDS

The results of Experiment 1 furnished initial support for the experimental hypothesis that people's prior encoding experiences affect their assessments of elapsed time. The obtained findings also called into question the traditional content-based explanation of retrospective duration estimation (cf. Ornstein, 1969). Of potential relevance, however, is that the present experiential effects were obtained in a task context in which participants were required to commit different sets of items to memory during the critical interval (i.e., high- vs. low-frequency words). Although

participants' ratings of task difficulty revealed that the ease of encoding manipulation was successful, it is possible that subtle differences in the lexical status of the items may have contributed to the observed effects.

Perhaps then a better test of the experimental prediction would be to hold the informational content (i.e., words to be encoded) constant across the two experimental conditions and manipulate the difficulty of encoding operations in an alternative way. In the current experiment, this will be achieved by varying the typeface in which a standard set of items are presented to participants (i.e., typed vs. handwritten). It was anticipated that participants would experience more difficulty memorising poorly handwritten rather than typed words. The predictions were as in Experiment 1. That is, if people rely on an experience-based judgmental strategy, then retrospective duration estimates should decrease as the encoding task is perceived to increase in difficulty. In contrast, if people rely on a content-based judgmental strategy, then retrospective duration estimates should closely parallel memory for the amount of information remembered from the encoding task.

2.3.1 Method

Participants and Design

Thirty-two female undergraduates from the University of Bristol participated in the experiment in partial fulfilment of a course requirement. The study had a single factor (typeface: typed or handwritten) between-subjects design. A random assignment of participants to one of the experimental conditions was undertaken.

Stimulus Materials and Procedure

Participants were tested individually and informed that the study was an investigation into human memory. The experiment was basically a replication of the previous study, but with one important modification. In the study phase (again lasting for 90 s), participants were presented with the 20 high-frequency words used in Experiment 1. For half of the participants, the words were typed in lowercase letters (Times New Roman font, 12 point); for the others, the words were handwritten in a generally poor style which also appeared in lowercase (see Appendix 2). The presentation format of the to-be-remembered items was expected to influence the difficulty of the encoding

experience. The procedure and dependent measures were as in Experiment 1. At the end of the experiment, participants were debriefed, thanked, and dismissed. In the debriefing session, participants once again did not suspect that the experiment was primarily interested in their time estimation abilities and therefore were completely unaware that a retrospective duration judgment would be required.

2.3.2 Results and Discussion

Perceived Task Difficulty

To assess the encoding experiences associated with the memory task, a single factor (typeface: typed or handwritten) between-subjects ANOVA was performed on participants' difficulty ratings. This analysis confirmed that participants found the memory task to be less demanding when the to-be-remembered words were typed rather than handwritten, $F(1,30) = 3.83$, $p < .06$ (see Table 2 for treatment means). Although this analysis revealed only a marginal effect of typeface on participants' encoding experiences, the results fell in the predicted direction.

Duration Estimates

A single factor (typeface: typed or handwritten) between-subjects ANOVA was performed on the data. As expected, this revealed an effect of typeface on participants' duration judgments, such that more time was believed to have been available to memorise the typed rather than the handwritten words, $F(1,30) = 5.00$, $p < .04$ (see Table 2 for treatment means). This pattern of findings is consistent with what would be expected if participants used their prior encoding experiences as a source of information for judgment.

Free Recall Performance

Total correct proportional recall scores were submitted to a single factor (typeface: typed or handwritten) between-subjects ANOVA. This analysis revealed no effect of typeface on recall performance, $F(1,30) < 1$, *ns* (see Table 2 for treatment means). This suggests that participants must have expended greater effort memorising the handwritten words (see difficulty ratings below).

Table 2.

Mean Ratings of Duration (s), Task Difficulty, and Free Recall Performance as a Function of Typeface (standard deviations in parentheses)

Typeface	Duration Estimates	Task Difficulty	Free Recall
Typed	87.5 (12.25)	6.06 (1.65)	.334 (.10)
Handwritten	79.1 (8.80)	7.12 (1.41)	.350 (.08)

The observed pattern of time estimation results again presents difficulties for a content-based hypothesis of retrospective timing (Ornstein, 1969). The two memory tasks lasted for the same clock duration, contained identical stimulus items that were processed and remembered to the same degree, but they were not judged as equal in perceived duration. Thus, as no relationship was found between duration estimates and memory for the interval items, participants could not have used a judgmental strategy based on memory content. As the only physical difference between the memory tasks was the presentation format of the to-be-remembered items, the experience-based hypothesis provides the best explanation of the current findings. Specifically, participants appeared to rely on a judgmental strategy based on their experienced ease or difficulty of encoding to infer the time elapsed during the task. When the word-encoding task was perceived as difficult (i.e., handwritten) rather than easy (i.e., typed), participants judged that less time had been available to commit the items to memory.

Duration Estimates and Difficulty Ratings

Further evidence for this conclusion was obtained by a correlational analysis. Participants' duration estimates decreased as their reported difficulty of encoding the words increased, $r(30) = -.448$, $p < .01$. As the results satisfied the conditions for testing mediation (Baron & Kenny, 1986), an ANCOVA was performed to establish if the subjective difficulty of encoding operations mediated the effect of typeface on participants' duration estimates. This revealed that when task difficulty ratings were partialled out of the analysis, the effect of typeface on duration estimates was

eliminated, $F(1,29) < 1$, *ns*. This confirms that the experienced ease or difficulty of encoding mediated participants' judgments of remembered duration.

Thus replicating Experiment 1, the present findings again show that people pay attention to their prior encoding experiences and use the information they provide to guide their judgments of elapsed time. Extending the previous results, on this occasion the contents of the to-be-remembered words were constant across conditions whilst encoding difficulty was manipulated by varying the typeface in which these items were presented.

2.4 EXPERIMENT 3: TYPED vs. HANDWRITTEN PERSONALITY TRAITS

The results thus far demonstrate a relationship between the subjective difficulty of prior encoding operations and people's retrospective duration judgments. Interestingly, in both Experiments 1 and 2, participants were given explicit instructions by the experimenter to study and memorise the presented stimulus items. Perhaps, these instructions cause participants to pay more attention to their encoding experiences than would otherwise be the case. The question remains, therefore, whether similar effects would emerge in task contexts in which participants are not required (at least explicitly) to commit items to memory. This issue will be addressed in the present experiment. Imagine a situation in which a tall dark attractive stranger approaches you whilst sitting in a bar. As he or she is making polite chit chat, no doubt you will be listening carefully and hanging on each and every word so that you can form some kind of impression of that person. Some recent work discussed previously has shown that the experience of ease or difficulty evoked by processing operations is used as a relevant source of information to guide our impressions of another person (Dijksterhuis et al., 1999). Suppose then that you were asked in retrospect how long it took you to form an impression of that person. Would the same type of experiential information be used to come up with an answer?

Based on such a task context, participants will be given a series of personality traits that are said to describe a particular target. Their task will be to form an impression of this person. Previous research has shown that an impression-set functions as an implicit memory instruction (Hamilton, Katz, & Leirer, 1980). That is, although no

mention is made of the need to remember the presented items. an impression-set prompts participants to memorise the personality descriptors. As in Experiment 2, the exact same items will be used in the two experimental conditions and the difficulty of encoding operations will be manipulated by varying the typeface in which these items are presented to participants (i.e., typed vs. handwritten traits). Developing the procedures used in the initial experiments, a couple of modifications will be made to the methodology. First, the temporal interval of interest will be reduced to 46 s. This will assess the extent to which the reported effects extend to shorter time periods. Second, a judgment of the confidence with which an impression is held will be used as a proxy for the difficulty of the impression-formation task. In the present context, a question about confidence seemed more appropriate and provides another way to measure participants' experienced ease or difficulty of encoding. This assumption is based on previous research which has found that ratings of confidence and task difficulty are correlated (e.g., Kelley & Lindsay, 1993; Wänke et al., 1996). Specifically, people feel less confident in their judgments when they find a task to be difficult rather than easy. The experimental predictions (the experience-based hypothesis) and Ornstein's predictions (the content-based hypothesis) were as in the previous experiments.

2.4.1 Method

Participants and Design

Twenty-eight female undergraduates from the University of Bristol were paid £3 for their participation in the experiment. The study had a single factor (typeface: typed or handwritten) between-subjects design. Participants were randomly assigned to one of the experimental conditions.

Stimulus Materials

Two word lists were prepared. Both lists comprised 20 personality traits that described a girl called "Mary" (e.g., *compassionate*, *unusual*, *impatient*). These items were selected from Anderson's (1968) word pool of personality traits and were presented in a vertical column on a sheet of paper. In one list, the trait words were typed in lowercase letters (Times New Roman font, 12 point); in the other, the same

trait words were handwritten in a generally poor style using lowercase letters (see Appendix 3 for a full listing of the stimulus trait words and typeface used).

Procedure

Participants arrived at the laboratory individually and were told that they would be taking part in a study on person perception. Participants' attention was then drawn to the sheet of paper placed face down on the table in front of them. It was explained that the sheet contained 20 personality traits that described a girl called "Mary" and their task was to form an impression of her using the words available to them. No information was given as to the time allowed to complete this task. Half of the participants studied the typed trait words and the other half studied the handwritten trait words. Participants turned over the list when the experimenter said "start" and a 46 s interval was timed using a concealed stopwatch. At that point, the experimenter said "stop" and the list was removed. In this way, the task interval (i.e., to-be-assessed duration) was clearly defined. Following the impression-formation task, participants were instructed to write down as many countries of the world as they could remember. This distractor task lasted for 5 min and was secretly timed using a stopwatch. However, participants were unaware of the amount of time that had elapsed during the task.

Next, participants completed two questions that related to the impression-formation task. The order of presentation of the questions was counterbalanced across the two experimental conditions. Participants were asked to estimate how much time they had been given to form an impression of Mary. They were reminded that the duration to-be-estimated began when the experimenter said "start" and finished when they heard the word "stop". A 7-point scale was provided for the retrospective duration judgment ranging from 37-55 s with 3 s intervals between each point. Participants were asked to circle one of the points and were encouraged to be as accurate as possible. Participants were also required to rate how confident they were that their impression of Mary was accurate. Ratings were made along a 7-point scale ranging from '*not at all confident*' (1) to '*extremely confident*' (7). Finally, participants were instructed to write down all the personality trait words they could remember from the presented list in the space provided on the question sheet. Participants were told that they could take as much time as they needed to complete this task. In the debriefing session that followed, participants were probed for suspicion as to the real purpose of

the study. No participant guessed that time estimation was the main area of interest and none had suspected that a retrospective duration judgment would be required. Participants were then thanked, paid, and dismissed.

2.4.2 Results and Discussion

Perceived Task Confidence

To ensure that the impression-formation task was accompanied by different encoding experiences, participants' confidence ratings were submitted to a single factor (typeface: typed or handwritten) between-subjects ANOVA. As expected, this revealed an effect of typeface on participants' perceptions of impression confidence, $F(1,26) = 7.67$, $p < .01$. Participants felt more confident that their impression of Mary was accurate when the presented trait words were typed rather than handwritten (see Table 3 for treatment means).

Duration Estimates

A single factor (typeface: typed or handwritten) between-subjects ANOVA was undertaken on the data. As expected, this revealed an effect of typeface on participants' judgments of elapsed time, $F(1,26) = 5.50$, $p < .03$. Participants believed that they were given more time to form an impression of Mary when the presented trait words were typed rather than handwritten (see Table 3 for treatment means). Once again, this pattern of findings is consistent with what would be expected if participants used their experienced ease or difficulty of encoding as a source of information for judgment.

Free Recall Performance

Total correct proportional recall scores were submitted to a single factor (typeface: typed or handwritten) between-subjects ANOVA. This analysis revealed a marginal effect of typeface on recall performance, $F(1,26) = 3.37$, $p < .08$. Participants remembered slightly more trait words when they were presented in a typed rather than a handwritten format (see Table 3 for treatment means).

Table 3.

Mean Ratings of Duration (s), Task Confidence, and Free Recall Performance as a Function of Typeface (standard deviations in parentheses)

Typeface	Duration Estimates	Task Confidence	Free Recall
Typed	47.5 (5.85)	4.92 (1.14)	.468 (.11)
Handwritten	42.6 (5.24)	3.50 (1.56)	.396 (.10)

Unlike the previous studies, the encoding task that was judged to have lasted for a longer time period also produced slightly better free recall scores (i.e., typed trait words). To be overly cautious in interpreting the present data, this relationship (albeit weak) between participants' duration estimates and their memory for the interval items could lend some support to Ornstein's (1969) storage-size hypothesis. However, if judgments of remembered duration are based *solely* on the amount of information stored in memory as this hypothesis suggests, then one would expect to find evidence of a stronger relationship between these two variables. As this was not the case, the pattern of time estimation results is best explained by the experience-based hypothesis. Participants' retrospective duration judgments of the impression-formation task were influenced by the ease or difficulty they experienced encoding the presented trait words. Less time was reported to be available to form a target-based impression when the encoding task was considered to be difficult (i.e., handwritten traits) and more time was reported to be available when the encoding task was considered to be easy (i.e., typed traits).

Duration Estimates and Confidence Ratings

Further support for this interpretation can be garnered from the results of a correlational analysis. Participants' duration estimates and their ratings of impression confidence (proxy for difficulty) were correlated, such that duration estimates decreased as perceived confidence in the impression decreased, $r(26) = .534$, $p < .005$. As the results met with the criteria required for testing mediation (Baron & Kenny, 1986), an ANCOVA was performed to establish if the experienced ease or difficulty of encoding mediated the effect of trait typeface on participants' duration

estimates. On this occasion, however, perceived task confidence was used as the covariate. This analysis revealed that when confidence ratings were partialled out of the analysis, the effect of typeface on duration estimates was eliminated, $F(1,25) < 1$, *ns*. Thus, the experienced ease or difficulty evoked by encoding operations mediated participants' judgments of remembered duration.

The results of this experiment replicate and extend the previous findings. Even without explicit instruction to commit the presented trait words to memory, people seem to take on board the information provided by their prior encoding experiences to infer how much time has elapsed. When the task of placing the information into mind is experienced as effortful and demanding, perceivers believe they had less time to form an impression of the target person. Presumably, by reporting the duration of the task to be shorter, perceivers can justify to themselves why they are not very confident in their impression. Conversely, when the task of placing information into the mind is considered to be a relatively effortless activity, perceivers believe they had more time to form an impression of the target person. This can potentially explain why perceivers reported greater confidence in their impression in this situation. Furthermore, the observed results extend those from the previous studies as the same ease of encoding effects emerged despite using a shorter duration interval (46 s) than in the other experiments (90 s). This therefore suggests that an experience-based strategy is employed for retrospective duration judgments across varying intervals, at least in the range investigated so far.

2.5 CHAPTER DISCUSSION

Although past research has emphasised the contents of memory as the principal determinant of remembered duration (Ornstein, 1969), the previous studies suggest that this may not provide a complete view of how a person estimates elapsed time. In all three studies, the amount of information presented during the to-be-judged interval was held constant and with the exception of Experiment 3 the amount of information remembered did not differ as a function of its nature (word frequency) or its appearance (typeface). Even the third study only found a marginal difference in recall scores as a function of trait typeface. A content-based model would have problems explaining why large differences in estimated duration were found between the two experimental conditions when the same amount of information was

apparently represented in mind. These results are consistent with previous retrospective temporal estimation research that has found no relationship between judgments of remembered duration and the amount of information recalled from the judged interval (e.g., Block, 1974; McClain, 1983; Poynter, 1983; Predebon, 1984).

The experience-based hypothesis can however provide a potential explanation for the reported findings. The characteristics of the to-be-encoded verbal material in Experiments 1-3 were sufficient for participants to have different encoding experiences (in terms of subjective ease or difficulty). When they were later unexpectedly asked to make a retrospective duration judgment, it seems that the experiential state that was associated with the encoding experience was used as a cue to compute elapsed time. When participants found it mentally demanding and difficult to encode the presented words, they interpreted this to mean that they must not have been given much time to perform the task. Thus, short retrospective duration judgments were provided by these participants. In contrast, when encoding information was deemed to be a relatively effortless affair, participants interpreted this to mean that they were given sufficient time to perform the task in a satisfactory manner. This was reflected in their longer retrospective duration judgments. The results of the mediational analyses in all three studies confirm this experience-based viewpoint. Specifically, people's subjective mental states are used to guide their judgments of remembered duration. As such, the present findings are compatible with related research in social cognition that highlights the role of subjective experiences in other domains of judgment (e.g., Clore, 1992; Kelley & Jacoby, 1996a; Schwarz, 1998; Schwarz & Clore, 1996; Strack, 1992). The question remains, of course, whether these ease of encoding effects on judgments of duration in retrospect would extend to other stimulus modalities, measures of memory, and longer temporal intervals? These issues will be considered in the next chapter.

CHAPTER 3

EXPERIMENTS 4-5

3.1 INTRODUCTION

In the initial three experiments, participants were required to visually encode the information presented during the critical task interval and differential demands were placed on the encoding process by varying the nature (Experiment 1) or the appearance of the to-be-remembered information (Experiments 2 and 3). Thus, in order to test the experience-based hypothesis further, it is necessary to determine whether the observed effects would extend to task contexts in which the information is transmitted in a different modality and the difficulty of encoding operations is manipulated in an alternative way. Thus, the two experiments in this chapter will investigate whether the subjective ease or difficulty of prior encoding operations guides people's retrospective duration judgments when the information is presented aurally. A successful replication of the results from the previous three experiments would show that experiential effects emerge regardless of the modality in which the information is perceived during the target interval. As in Chapter 2, the experience-based hypothesis will be competitively tested against Ornstein's (1969) storage-size hypothesis of remembered duration.

3.2 EXPERIMENT 4: ENGLISH vs. GERMAN ACCENT

To explore these issues in the present experiment participants will be required to perform an auditory encoding task during the critical interval. Imagine, for example, a situation in which you are eavesdropping on a conversation between two people in a restaurant (e.g., a couple arguing). Suppose further that you are later unexpectedly asked to estimate the duration of that conversation. Might it be the case that you use your subjective experience of how difficult it was to encode the conversation as a cue to make the retrospective duration estimate? Of course, for such a cue to be relevant to the temporal judgment, the encoding experience must have been considered effortful and mentally demanding in the first place. One situation in which the encoding process would be compromised in this way is when the conservation took place in a particularly noisy restaurant. Presumably then, the experience-based

prediction would be that the duration of the conversation should be judged as shorter in this situation compared to a quieter restaurant where the same conversation could be encoded much more easily.

In the present experiment, a functionally equivalent context will be created in the laboratory. Participants will be asked to listen carefully to a tape-recorded passage spoken by a female narrator. However, the difficulty of the encoding task will not be increased by using background noise, but rather by varying the accent in which the passage is spoken (i.e., English vs. Foreign). It was anticipated that native English speakers would have a harder time trying to encode the passage when it was spoken with a foreign accent (i.e., German) compared to an English accent. Of course, as the content-based model proposes that remembered duration is based on the amount of stimulus information processed and stored in memory during the judged interval (e.g., Ornstein, 1969), it is imperative to hold constant the actual contents of the passage in the easy (English accent) and difficult (German accent) encoding conditions. The passage comprises an anecdotal story of travelling experiences around Great Britain and includes the names of forty towns and cities. Participants will be asked to memorise these items for a subsequent memory test.

Developing the procedures used in the experiments discussed in Chapter 2, three modifications will be made to the methodology. First, the temporal interval to be estimated will be increased to 4 min 47 s. As this is a much longer duration than studied previously, this will assess the extent to which the reported effects generalise to extended temporal episodes. Second, the horizontal interval scale used for the retrospective duration estimates will be adjusted to include minutes and seconds rather than just seconds. This is a small but necessary alteration in the present context as time periods in this range are undoubtedly estimated in this way. Third, a recognition memory test will be administered to assess participants' recollections of the towns and cities from the passage. In the previous experiments, only a free recall test was used. As there was no necessary relationship between memory for the interval items and judgments of remembered duration, this was taken as evidence against Ornstein's (1969) storage-size hypothesis. Nevertheless, the argument could be made that the contents of memory seemed to play no role in shaping people's duration judgments because recall performance was an inadequate measure of the amount of information stored in memory (i.e., storage-size). The problem with this

defence is that Ornstein (1969) failed to specify a way of quantifying storage size. However, time estimation researchers assume that memory measures of both recall and recognition are positively correlated with the size of memory storage (e.g., Block, 1974, 1992; Hanley & Morris, 1984; McClain, 1983; Poynter, 1983; Predebon, 1984). Thus, to further test the storage-size hypothesis of remembered duration, recognition accuracy will be measured as another way to assess the amount of information held in memory.

As long as the accent manipulation is successful in eliciting different encoding experiences for participants in the two experimental conditions, the experience-based predictions should hold. Retrospective duration estimates of the passage should be shorter when the encoding task is experienced as difficult (i.e., German accent) rather than easy (i.e., English accent). In contrast, the content-based prediction is that retrospective duration estimates of the passage should closely parallel memory for the amount of information remembered from the encoding task.

3.2.1 Method

Participants and Design

Forty undergraduate students (20 men and 20 women) were recruited from a psychology subject pool at the University of Bristol and received course credit for their participation in the experiment. All participants were native speakers of English and had normal hearing. An equal number of male and female participants were randomly assigned to the conditions of a single factor (accent: English or German) between-subjects experiment.

Stimulus Materials

Using a Sony tape recorder, two tape-recorded passages were prepared. On the first tape, a German female narrator read aloud a long fictional story written in the first person about her travelling adventures around Great Britain. Critically, 40 towns and cities (e.g., *Crewe*, *Luton*, *Newcastle*; see Appendix 4 for the stimulus passage used; the to-be-remembered items are written in bold) were mentioned during the course of the passage. The tape-recorded passage lasted for 4 min 47 s. On the second tape, an English female narrator was recorded reading the same story. To ensure that the

recording lasted for an equivalent period of time, the narrator shadowed the German speaker on the first tape using headphones. With much practice and a lot of patience on the narrator's part, the two tapes were identical in length. An additional 40 towns and cities were selected to serve as distractors in the recognition test (see end of Appendix 4). Each distractor item was chosen to match a target item in approximate geographical location, town size, and number of syllables.

Procedure

Participants arrived at the laboratory individually and were informed that the study was an investigation into human memory. Participants were instructed to listen carefully to a tape-recorded passage spoken by a female narrator. For half of the participants, the narrator was English; for the others, she was German. Participants were informed that a number of towns and cities would be mentioned throughout the course of the passage and were instructed to remember these items as afterwards their memory for the items would be assessed. No information was given regarding the length of the listening task, but it was delimited for the participants by the experimenter saying "start" and "stop". Following this, participants performed a number searching task for a 5 min period that was accurately timed using a concealed stopwatch. This served as a distractor task to clear short-term memory and again, participants were unaware of how long they had been working on the task.

Participants were then required to answer two questions concerning the listening task with the order counterbalanced across the two experimental conditions. One question required the participants to estimate how much time (in min and sec) they had spent listening to the passage. All participants were reminded that the interval of time to be estimated was delimited by the words 'start' and 'stop'. A 9-point scale was provided, ranging from 3 min 30 s to 5 min 30 s with 15 s intervals between each point. Participants were asked to circle the point that most accurately captured the duration of the passage. The other question asked participants to rate, on a 9-point scale, how difficult they found it to memorise the towns and cities from the passage (1 = *very easy*; 9 = *very difficult)*. Finally, a recognition memory test was administered to assess participants' recollections of the passage. Participants were presented with a typed list of 80 towns and cities in three vertical columns (40 targets & 40 distractors). The sequence of towns and cities was randomised. Participants were instructed to indicate whether each item had been heard earlier in the passage

(write "O" for old) or had not been heard earlier in the passage (write "N" for new). On completion of the recognition task, participants were debriefed as to the nature of the research, thanked for their assistance, and dismissed. None of the participants guessed that they would be asked to make a retrospective duration judgment.

3.2.2 Results and Discussion

Perceived Task Difficulty

To investigate the encoding experiences associated with the memory task, a single factor (accent: English or German) between-subjects ANOVA was performed on participants' difficulty ratings. This analysis confirmed that accent had the intended effect on perceived difficulty. Participants found it easier to memorise the towns and cities from the passage when these items were delivered in an English rather than a German accent, $F(1,38) = 46.05$, $p < .0001$ (see Table 4 for treatment means).

Duration Estimates

Participants' retrospective duration estimates were converted to seconds and the resultant data were submitted to a single factor (accent: English or German) between-subjects ANOVA. As expected, this revealed an effect of accent on participants' duration judgments, such that the passage was believed to be longer when it was delivered in an English rather than a German accent, $F(1.38) = 107.67$, $p < .0001$ (see Table 4 for treatment means).

Recognition Accuracy

For each participant the number of correctly recognised towns and cities was corrected for guessing by subtracting the false-alarm rate from the hit rate. That is, the number of distractor towns and cities incorrectly recognised was subtracted from the total number actually recognised (Baddeley, 1990). The corrected number was then converted into a proportional score which served as a measure of recognition accuracy. The resultant scores were submitted to a single factor (accent: English or German) between-subjects ANOVA. This revealed an effect of accent on recognition accuracy, such that participants correctly recognised more towns and cities from the passage when these items were delivered in an English rather than a German accent, $F(1,38) = 9.04$, $p < .005$ (see Table 4 for treatment means).

Table 4.

Mean Ratings of Duration (s), Task Difficulty, and Recognition Accuracy as a Function of Accent (standard deviations in parentheses)

Accent	Duration Estimates	Task Difficulty	Recognition
English	285 (16.86)	3.95 (1.67)	.664 (.12)
German	234 (14.10)	6.75 (0.79)	.533 (.15)

Duration Estimates and Difficulty Ratings

To analyse the relationship between participants' duration estimates and ratings of encoding difficulty, a correlational analysis was conducted. This revealed that these two variables were correlated, such that duration estimates decreased as encoding operations were perceived to increase in difficulty, $r(38) = -.676$, $p < .001$. As the results fulfilled the conditions required for testing mediation (Baron & Kenny, 1986), an ANCOVA was performed to assess whether the subjective difficulty of encoding mediated the effect of accent on participants' duration estimates. When difficulty scores were partialled out of the analysis, the effect of accent on duration estimates was reduced, but not eliminated, $F(1,37) = 40.99$, $p < .0001$. Thus, as in the previous studies, the experienced ease or difficulty of encoding exerted a mediational influence on participants' retrospective duration judgments, although this effect was not as pronounced in the current experiment.

The current results replicate and extend those observed in Experiments 1-3. As before, judgments of remembered duration were influenced by the subjective difficulty of a prior encoding episode, even when the information was presented aurally rather than visually. When the auditory encoding task was considered to be subjectively easy (i.e., English accent), participants believed that more time had been spent listening to the passage. In contrast, when the encoding task was considered to be subjectively difficult (i.e., German accent), participants believed that less time had been spent listening to the passage. Thus, the differences found in judged duration are consistent with what would be expected if individuals relied on their prior encoding experiences as a source of information to compute how much time had

elapsed during the task. This provides supporting evidence that ease of encoding effects generalise across different perceptual modalities. In addition, the observed findings also extend the previous work as the objective clock time duration of the estimated interval was much longer than in any of the earlier studies, nevertheless comparable effects emerged.

The results of the mediational analysis lend further support to this experience-based account of retrospective timing. Specifically, this analysis revealed that the subjective ease or difficulty of prior encoding operations plays an influential mediational role in people's judgments of remembered duration. However, unlike the mediational analyses conducted for the experiments in Chapter 2, the effect of the independent variable (i.e., accent) on duration estimates was not eliminated completely when difficulty scores were partialled out of the analysis. Undoubtedly, this failure to completely eliminate the effect of accent on participants' duration estimates is due to the magnitude of the original effect. Perhaps one explanation for the enormity of this effect is that more information had to-be-encoded in this experiment than in the initial three studies (40 vs. 20 words). It is also possible that the presentation modality of the information may have been a contributory factor (auditory vs. visual).

The results of this study are therefore consistent with the idea that people use their experienced ease or difficulty of encoding as a cue to estimate elapsed time. However, there is one obvious problem in interpreting these results as unequivocal support for the experience-based hypothesis. Unlike the previous studies, the observed pattern of time estimation results also corroborates Ornstein's (1969) storage-size hypothesis of remembered duration. The encoding task that was judged as longer in duration (i.e., the passage narrated in an English accent) also produced better recognition memory for the to-be-remembered items (i.e., towns and cities). Thus, as retrospective duration judgments were directly related to the amount of information recognised from the judged interval, people could also have used the amount of information stored in memory as a judgmental cue to infer elapsed time. In the earlier experiments, such a content-based explanation was discounted as there was no relationship between judgments of remembered duration and memory for the interval items. Of potential relevance, however, is that only recall performance was assessed. This raises the question of whether a positive relationship between these

two variables was not found previously because a recognition test rather than a free recall test provides a better index of the amount of information held in memory. Obviously, the only way to address this issue is to investigate whether the same memory content effects emerge in a conceptual replication of this experiment. That is, will duration judgments again closely parallel memory for the amount of information recognised from the judged interval? It is important to note that other retrospective temporal estimation research has failed to find evidence of this relationship (e.g., Block, 1978, 1986, 1992; Block & Reed, 1978: Hanley & Morris, 1982; Poynter, 1983).

3.3 EXPERIMENT 5: ENGLISH vs. GREEK ACCENT

Given that the results of Experiment 4 lend support to both the experience-based and content-based hypotheses of remembered duration, a conceptual replication would be welcome to determine the basis of the observed effects. That is, will ease of encoding effects on judgments of temporal duration emerge, and if so, will they occur in the presence of memory performance differences as in Experiment 4, or in the absence of memory performance differences as in Experiments 1-3? The present experiment will investigate these issues.

As in the previous study, participants will be asked to listen carefully to a tape-recorded passage spoken by a narrator and the difficulty of the encoding task will be manipulated by varying the accent in which the passage is spoken (i.e., English vs. Foreign). However, on this occasion, the narrator will be male and the foreign accent will be Greek. Once again, it was anticipated that native English speakers would experience more difficulty encoding the passage when it was spoken with a foreign accent compared to an English accent. As before, the contents of the passage were identical in both the easy (English accent) and difficult (Greek accent) encoding conditions. However, a modification will be made to the subject matter of the passage. Specifically, the passage comprises a recipe and cooking procedure for an unspecified dish and includes the names of 40 different ingredients. Participants will be given the task of memorising these items and they will be forewarned that a memory test will follow. As in the previous experiment, the test will assess recognition memory. A final modification to the earlier methodology involves the duration of the temporal interval to be estimated. In the current experiment, the

passage will last for 3 min 18 s. By using a different clock time duration, the generality of the findings can be examined further.

The experimental predictions (experience-based hypothesis) and Ornstein's predictions (content-based hypothesis) were as in the previous experiments. If people use their prior encoding experiences to compute elapsed time, then duration estimates should be shorter when the encoding task is deemed to be difficult rather than easy. In contrast, if people draw on the amount of stimulus information stored in memory, then duration estimates should closely parallel memory for the amount of information remembered from the encoding task.

3.3.1 Method

Participants and Design

Forty undergraduate students (20 men and 20 women) were recruited from a psychology subject pool at the University of Bristol and received course credit for their participation in the experiment. All participants were native speakers of English and had normal hearing. The study had a single factor (accent: English or Greek) between-subjects design with an equal number of men and women randomly assigned to each condition.

Stimulus Materials

The stimulus materials comprised of two tape-recorded passages spoken by a male narrator. In both passages, the narrator described a recipe and cooking procedure for an unspecified dish. Critically, 40 ingredients (e.g., *fennel*, *sugar*, *lamb*; see Appendix 5 for the stimulus passage used; the to-be-remembered items are written in bold) were mentioned during the course of the passage. The recipe itself was entirely fictional so participants with any cooking knowledge would be unable to predict the identity of the dish. The only difference between the two tape-recorded passages was whether the narrator was English or Greek. As in Experiment 4, a shadowing technique was employed to create two recordings that were equal in length, both lasting for a total duration of 3 min 18 s. An additional 40 ingredients were selected to serve as distractors in the recognition test (see end of Appendix 5). Each distractor item was chosen to match a target item based on food-type and number of syllables.

Procedure and Dependent Measures

Participants arrived at the laboratory individually and were informed that the study was an investigation into human memory. The same procedure and dependent measures were employed as in Experiment 4, with the exception of the horizontal interval scale used for participants' duration estimates. This was adjusted to fit the shorter listening period of the passage. A 9-point scale was provided ranging from 2 min to 4 min with 15 s intervals between each point. At the end of the experiment, participants were debriefed as to the nature of the research, thanked for their assistance, and dismissed. Once again, none of the participants suspected that the experiment was concerned with time estimation and therefore were completely unaware that a retrospective duration judgment would be required.

3.3.2 Results and Discussion

Perceived Task Difficulty

To assess whether the memory task was accompanied by different encoding experiences, participants' difficulty ratings were submitted to a single factor (accent: English or Greek) between-subjects ANOVA. This analysis confirmed that subjective experiences of encoding difficulty varied as a function of accent. Participants found it easier to memorise the ingredients from the passage when these items were delivered in an English rather than a Greek accent, $F(1,38) = 15.39$, $p < .0004$ (see Table 5 for treatment means).

Duration Estimates

Participants' retrospective duration estimates were converted to seconds and the resultant data were submitted to a single factor (accent: English or Greek) between-subjects ANOVA. As expected, this revealed an effect of accent on participants' duration judgments, such that the passage was judged as longer when the recipe was delivered in an English rather than a Greek accent, $F(1,38) = 28.44$, $p < .0001$ (see Table 5 for treatment means). As participants' estimates of elapsed time varied as a function of their experienced ease or difficulty of encoding, this provides additional support for the experienced-based hypothesis.

Recognition Accuracy

Recognition accuracy (hits minus false-alarms) was computed for each participant as a proportion. The corrected proportional scores were submitted to a single factor (accent: English or Greek) between-subjects ANOVA. This analysis revealed that recognition accuracy was not affected by the accent in which the passage was spoken, $F(1,38) < 1$, *ns*. Participants correctly recognised the same number of ingredients from the passage regardless of whether these items were delivered in an English or a Greek accent (see Table 5 for treatment means). This suggests that participants must have expended greater effort memorising the ingredients when the narrator was Greek (see difficulty ratings below).

Table 5.

Mean Ratings of Duration (s), Task Difficulty, and Recognition Accuracy as a Function of Accent (standard deviations in parentheses)

Accent	Duration Estimates	Task Difficulty	Recognition
English	191 (27.04)	4.40 (1.67)	.609 (.17)
Greek	154 (16.05)	6.20 (1.20)	.544 (.14)

Duration Estimates and Difficulty Ratings

Further evidence that retrospective duration estimates were influenced by the subjective difficulty of prior encoding experiences was obtained by a correlational analysis. Specifically, participants' estimates of temporal duration were shorter when they found the encoding task to be difficult, $r(38) = -.703$, $p < .001$. As the results satisfied the conditions for testing mediation (Baron & Kenny, 1986), an ANCOVA was performed on the data. This analysis revealed that when the subjective difficulty of the encoding task was partialled out of the analysis, the effect of accent on duration estimates was reduced, but not eliminated, $F(1,37) = 10.01$, $p < .003$. Thus, as in the previous studies, the experienced ease or difficulty of encoding exerted a mediational influence on participants' judgments of remembered duration, but again this effect was not as pronounced when performance was indexed by recognition accuracy rather than free recall.

In Experiment 4, the time estimation results could be explained by both the experience-based and content-based hypotheses. Thus, the prime objective of the current study was to replicate that experiment to determine the generality of the observed effects. With regard to the experience-based hypothesis, the present findings closely replicate those found previously despite using a different foreign accent and a different content domain in the passage. Participants' retrospective duration judgments were influenced by the ease or difficulty they experienced committing the items to memory. When the auditory encoding task was perceived as difficult (i.e., Greek accent) rather than easy (i.e., English accent), participants judged the duration of the passage to be shorter. This provides support for the notion that people pay attention to their prior encoding experiences and use the information they provide to guide their judgments of elapsed time. Moreover, as a different clock time duration was used, the generality of these findings is extended further.

However, with regard to the content-based hypothesis, the present findings fail to replicate those found in Experiment 4. Previously, retrospective duration judgments were directly related to the amount of information recognised from the passage. In contrast, in the present study no such relationship was found. There were large differences in remembered duration between the two auditory encoding tasks, but recognition accuracy for the passage items was equivalent. If people had used the amount of information stored in memory as a cue to judge elapsed time, then the two tasks should have been judged as equal in duration. These findings are consistent with previous research that has observed differences in judged duration that are not related to a recognition measure of participants' memory for the interval items (e.g., Block, 1992; Hanley & Morris, 1982; Poynter, 1983). The inference can therefore be made that the contents of memory played no role in shaping people's judgments of remembered duration. Thus, as ease of encoding effects were obtained in the absence of memory performance differences, it can be concluded that people based their retrospective duration judgments on the subjective ease or difficulty of prior encoding operations.

3.4 CHAPTER DISCUSSION

In both experiments, the time estimation results were identical. The passage narrated with an English accent was judged as longer in duration than the same passage

narrated with a German (Experiment 4) or a Greek (Experiment 5) accent. The content-based hypothesis of remembered duration (Ornstein, 1969) encounters problems in explaining these results as the expected positive relationship between duration judgments and memory for the interval items was not always found. The amount of information remembered from the passage differed as a function of accent in Experiment 4, but this was not the case in Experiment 5. These inconsistent memory content effects emerged despite using a recognition test which provides a sensitive measure of the amount of information stored in memory (Higgins & Bargh, 1987; Tulving & Pearlstone, 1966). Taken together then, these findings fail to corroborate a content-based account of retrospective duration estimation.

The experience-based hypothesis on the other hand can adequately explain the observed results. The accent in which the to-be-remembered items from the passage were spoken elicited different encoding experiences for participants in the two experimental conditions. That is, participants found it easy to encode the items when they were delivered in an English accent and they found it difficult to encode the items when they were delivered in a foreign accent. When the retrospective duration judgment was unexpectedly called for and participants considered the temporal interval, they used the experiential mental state that was associated with the encoding experience as a cue to judge elapsed time. Participants who had experienced ease whilst encoding the items interpreted this to mean that plenty of time must have been available to commit these items to memory. Thus, long retrospective duration judgments were provided by these participants. In contrast, participants who had experienced difficulty encoding the items interpreted this to mean that not much time had been available to commit these items to memory. This was reflected in their shorter judgments of elapsed time. The results of the mediational analyses in both studies confirm this experience-based account of remembered duration, although the effects were less pronounced than those observed in the earlier experiments in this thesis.

Thus far, the current research suggests that the content-based account of retrospective timing provides an incomplete view of how people estimate elapsed time. Another source of information that people seem to use is the subjective experience of ease or difficulty associated with prior encoding operations. Ease of encoding effects were obtained in task contexts in which the information was

presented visually or aurally, and without affecting recall or recognition performance. This demonstrates the generality of these findings across different stimulus modalities and measures of memory. Moreover, these effects were consistent across various objective clock time durations, all within the second and minute range, typically studied in retrospective temporal estimation research. In combination, this work provides a strong case for the influential role of experiential information in the construction of retrospective duration judgments; at least in task contexts similar to those used here. In demonstrating this, the present research corroborates and adds uniquely to related work in social cognition which has shown that subjective experiences can function as a highly informative cue in many domains of judgment (e.g., Clore, 1992; Kelley & Jacoby, 1996a; Schwarz, 1998; Schwarz & Clore, 1996; Strack, 1992).

In the following chapter, the experience-based hypothesis will be tested further by investigating whether the subjective experience of ease or difficulty evoked by retrieval operations also serves as a useful source of information for estimating elapsed time. There is no compelling a priori reason why this should not be the case. This assumption is based on the notion that it is not the processing operation per se that is important to the judgment, but rather the experience of ease or difficulty that was associated with it. Before this investigation can take place, one other issue needs to be addressed.

In the temporal estimation literature, there are two dominant explanations of how people form an impression of elapsed time. The research to date has shown little support for Ornstein's (1969) storage-size hypothesis, but the other influential account has not been considered. As discussed in the introductory chapter of this thesis, Block's (1978, 1989a, 1990; Block & Reed, 1978) contextual-change hypothesis predicts that retrospective duration judgments increase with the number of salient contextual changes that are experienced and stored in memory during the critical interval. The primary reason for not testing the contextual-change hypothesis so far is the difficulty encountered in deriving unequivocal predictions from it. The model itself fails to incorporate any independent way of measuring the amount of change in cognitive context that occurs in a given situation and it is not always clear what actually constitutes contextual change. In one of Block's many papers, he proposes that 'changes in process context, environmental context, emotional context,

and other contextual elements' (1992, p. 151) are all types of contextual change that can influence people's judgments of remembered duration. This rather unconstrained definition makes it difficult to predict whether a given experimental manipulation will have an effect on the amount of change experienced during the to-be-judged interval (Predebon, 1988).

In Experiments 1-5, the subjectively easy encoding task was always remembered as longer in duration than the subjectively difficult encoding task. The contextual-change hypothesis would have to explain this consistent pattern of findings by assuming that the easy task caused more contextual changes to be encoded and stored in memory than the more difficult version of the task. It is uncertain, however, why this should be the case. No attempt was made to deliberately manipulate contextual factors. In fact, with the exception of the first experiment, the informational content (i.e., words to be encoded) was identical in the two tasks and there were no environmental changes in any of the studies. It could also be stated that if a task is considered to be difficult or demanding, then performance on that task is usually accompanied by a larger number of mental events and more changes in affective reactions than a task which is considered less taxing. In this case, the difficult task should have produced longer rather than shorter retrospective duration judgments. Nevertheless, it is still possible that unintentional, but additional contextual influences were operating during the easy task which were stored in memory and caused it to be judged as longer in duration.

Obviously then, to test the predictive utility of Block's (1990; Block & Reed, 1978) hypothesis, the amount of contextual change that takes place during the critical interval has to be manipulated directly to determine whether it plays an influential role in shaping people's judgments of remembered duration. This will be attempted in Experiments 7 and 8 in the following chapter. These two experiments will competitively evaluate the predictions derived from the experience-based, content-based, and contextual-change hypotheses. Experiment 6 on the other hand will not attempt to manipulate contextual change. Rather, this experiment will logically follow on from the previous studies discussed by investigating whether people rely on their experienced ease or difficulty of retrieval as a basis for estimating elapsed time, or on the amount of information they have stored in memory.

CHAPTER 4

EXPERIMENTS 6-8

4.1 INTRODUCTION

The research reported thus far provides strong evidence that experiences associated with prior encoding operations serve as useful information in the construction of retrospective duration judgments. Extending this work, the three experiments in this chapter will investigate the extent to which the subjective ease or difficulty of prior retrieval operations influences people's judgments of remembered duration. That is, will people use their experiences of how easy or difficult it was for them to bring certain items of information to mind as a cue to estimate how much time has elapsed during a task? A successful replication of the previous results would provide support for the notion that it is not the memory processing operation per se that acts as input to the retrospective duration judgment, but rather the experience of ease or difficulty that was associated with the cognitive process. To investigate this issue, memory tasks will not be used as in the previous experiments. Instead, participants will be required to perform an easy or a difficult generation task during the to-be-judged interval. As in Chapters 2 and 3, the experience-based hypothesis will be competitively compared against Ornstein's (1969) storage-size hypothesis of remembered duration.

Typically, studies in social cognition that assess the role of retrieval experiences on judgment formation have used generation tasks which require participants to retrieve information from memory that is relevant to the subsequent judgment. For example, Schwarz, Bless, et al. (1991) asked participants to recall examples of their own assertive or unassertive behaviour prior to rating their level of assertiveness. In this research domain, directly equating the dependent measure with the retrieval task is a necessary methodological requirement to determine whether the descriptive contents of memory retrieval or the ease or difficulty of memory retrieval is used as a basis for judgment. In the current research, however, the information provided in the retrieval task does not have to relate in any way to the dependent measure (i.e., judgments of duration in retrospect). This is due to the fact that the traditional account of retrospective timing only regards the contents of memory (i.e., products of

retrieval) and not the descriptive implications of that information to be the critical factor that drives people's judgments of remembered duration (Ornstein, 1969). Naturally then, this left me with a decision regarding what kind of information to include in the retrieval task. After much deliberation, exemplar generation tasks, used frequently, in cognitive neuropsychology to assess frontal functioning, were chosen (Shallice, 1988).

4.2 EXPERIMENT 6: ANIMAL-GENERATION TASK (CUE CARDS PRESENT vs. ABSENT)

In the present experiment, the standard neurological test selected was a semantic category naming task. Specifically, participants will be asked to generate animal names during the critical interval. As in the previous experiments, the informational content (i.e., number of items to be generated) will be held constant across the two experimental conditions. All participants will be required to generate the names of 35 animals. Critically, participants must experience the same objective clock time duration during the generation task. To achieve this objective, a metronome will be set up to beep at regular intervals throughout the task. Participants will be instructed to generate an animal name each time a beep is heard. This simple procedure ensures that there are no differences between the two experimental conditions in the amount of information that is generated, or in the amount of time that elapses during the task.

To investigate the moderating role of prior retrieval experiences on judgments of remembered duration, it is essential that the animal-generation task places differential demands on the memory retrieval process (i.e., easy vs. difficult). Imagine for example that you were asked to generate the names of animals whilst at the zoo or at home. The specific location of the memory retrieval problem would undoubtedly cause you to have different retrieval experiences. Whilst visiting the zoo, the presence of a variety of animal species would enable you to generate animal names very easily. In stark contrast, generating animal names at home without the aid of such retrieval cues would somewhat increase the difficulty of the task.

In the present experiment, a functionally equivalent context will be created in the laboratory. The subjective demands of memory retrieval will be manipulated by presenting cue cards to half of the participants during the animal-generation task and

no cue cards to the other participants. It was anticipated that the presence or absence of cue cards would be sufficient for participants to have different retrieval experiences (i.e., easy vs. difficult respectively). To develop the procedures used in Experiments 1-5, three modifications will be made to the methodology. First, the duration of the task interval to be estimated will be different from any used previously (1 min 10 s). This will assess the extent to which the reported effects generalise to other temporal durations in the second and minute range. Second. the horizontal interval scale used for the retrospective duration judgments will be adjusted slightly. Previously, duration estimates were made via a circled response at a set point along the scale. However, in this experiment (and in those that follow), retrospective duration estimates will be made by making a mark along a fixed line length scale. As such, participants will be able to estimate the duration of the task to the nearest second. This alteration makes it possible to determine whether the reported effects extend to other duration judgment scales. Third, a surprise memory test will be administered. Due to the task context (i.e., animal names are self-generated during the task), a free recall test will be used to assess participants' memory for the generated interval items. Memory performance will serve as a measure of the amount of information stored in memory and thus will provide a direct test of the storage-size hypothesis (Ornstein, 1969).

As long as the cue card manipulation is successful in eliciting different retrieval experiences for participants in the two experimental conditions. the experience-based hypothesis predicts that retrospective duration judgments should decrease as the perceived difficulty of retrieval operations increase. That is, when the retrieval task is perceived to be difficult or demanding (i.e., cue cards absent), participants will report that less time was spent generating the animal names compared to when the retrieval task is perceived to be relatively easy (i.e., cue cards present). The content-based hypothesis predicts that retrospective duration judgments should closely parallel memory for the amount of information remembered from the task. That is, if the retrieval task leads to increased, decreased, or equivalent memory for the self-generated items compared to the other task, participants will report that more, less, or the same amount of time was spent generating the animal names.

4.2.1 Method

Participants and Design

Sixty-four undergraduates from the University of Bristol participated in the experiment and received chocolate bars as a small expression of appreciation. All participants were native English speakers and had normal hearing. The study had a single factor (cue: present or absent) between-subjects design. Four participants in the no-cue (difficult) condition either failed to generate an item at the appropriate time or used the same item more than once. Consequently, these participants were omitted from the data set. This strict omission criteria had to be adhered to as the number of items generated during the critical interval had to be same in both conditions so that the two competing explanations of remembered duration could be compared. This left 60 participants (30 men and 30 women) in the final statistical analyses with an equal number of men and women randomly assigned to each of the experimental conditions.

Apparatus

An electronic metronome was constructed specifically for the experiment (and the other experiments in this chapter) by a laboratory technician from the University of Bristol Psychology Department. This comprised a black plastic box measuring 12 cm x 10 cm x 5 cm. It was purposely designed to be discrete in appearance with no visible moving parts, unlike the moving pendulum of a traditional metronome. A dial was displayed on the side of the box ranging from 0.5 s to 15 s. The tempo of the metronome could be accurately set by adjusting the potentiometer in the middle of the dial. On this occasion, the metronome was set to beep at 2 s intervals. The beeps were audible through a speaker on the top of the box.

Procedure and Materials

Participants arrived at the laboratory individually and were informed that the study was an investigation into semantic memory. Participants' attention was then drawn to a metronome which was located on a table near to where the participants were asked to sit. The dial on the side of the metronome was not visible to participants. It was explained that the metronome would beep when it was turned on and their task was to generate out loud an item from a particular category to each beep of the

metronome. No information was given regarding the number of items that would have to be generated. The category of items chosen for the generation task was animal names. However, this was announced just before the metronome was turned on to prevent participants from thinking of examples as the rest of the procedure was being explained. Out of necessity because of these vague instructions, an example was given to ensure that participants understood what was meant by the term "a particular category". The experimenter gave the following instructions to all participants:

> For example, if the category was food, then you would have to say out loud a food item every time you hear a beep. For the first beep, you could say 'cheese', for the second beep, 'apple', and so on. Food is not the category chosen for the task. You will only be told what the category is just before the metronome is turned on.

Participants in the cue (easy) condition were also informed that throughout the generation task the experimenter would hold up a number of cue cards with subcategories boldly written on them. The following additional instructions were given to these participants:

> To explain how this will work, still imagine that the category items you will be generating are all types of food. When the task begins, the card could have the word 'fruits' written on it. Obviously fruit is a type of food. While this card is visible to you, you would have to say out loud the name of a fruit each time you hear a beep. For example, when you hear a beep, you could say 'banana', 'apple', and so on. When another card appears, the same applies. If the card has the word 'meats' written on it, then words such as 'pork' or 'chicken' should be given when you hear a beep.

Throughout the animal-generation task, five cue cards were displayed (A4 size, landscape orientation). Each card contained one of the following words: FARM, WILD, PETS, SEA, and BIRDS (handwritten in uppercase bold letters to fill the page). The cards were presented in this order. The first cue card was displayed as soon as the task began and after 7 animals relating to the named subcategory had

been generated, the next cue card was shown. For participants in the no-cue (difficult) condition, the animal-generation task was performed without the aid of cue cards so the above instructions were not given.

Once the relevant instructions were understood, all participants were told that the generation task would begin when the first beep was heard and would finish when the experimenter said "stop". In this way, the task interval (i.e.. to-be-assessed duration) was clearly defined. The experimenter then announced that the category was "animals" and turned on the metronome. During the task interval, all participants heard 35 beeps of the metronome, so 35 animal names were generated. The beeps occurred at 2 s intervals giving the task a total duration of 1 min 10 s. The experimenter noted down the animal names generated by each participant on a sheet of paper. This was done so that the number of animal names correctly recalled on a subsequent free recall test could be measured. This procedure also alerted the experimenter as to when the last beep would sound so the metronome could be turned off and the word 'stop' could be announced to delimit the end of the generation task. Following this, participants performed a distractor task in which they were required to circle all the two-digit numbers in a short booklet that were divisible by 7. Participants were not informed as to how long they would be given for the task. After 5 min had elapsed, which was accurately timed using a concealed stopwatch, the booklets were collected.

Participants were then presented with a short questionnaire consisting of two questions that related to the animal-generation task. The order of presentation of the questions was counterbalanced across the two experimental conditions. Participants were told to answer the questions in the order presented and to be as accurate as possible in their responses. One question required participants to estimate how much time they believed had elapsed during the generation task. Below this question was written: "You should consider this time period to have begun when you heard the first beep and to have finished when you heard the word 'stop'". A duration judgment scale was provided ranging from 30 s to 1 min 50 s with intervals of 10 s. Ticks to mark the 1 s intervals were also clearly indicated along its length. Participants were asked to estimate the duration of the task to the nearest second by making a mark on the scale. The other question required participants to rate how much difficulty they had experienced generating the animal names. Ratings were

made on a 9-point scale with 1 indicating '*very easy*' and 9 indicating '*very difficult*'. Finally, participants were asked to think back to the animal names they had generated earlier in the experiment and to write down as many as they could remember in the space provided on the question sheet. Participants were told that they could take as much time as they required on this task, but no participant took any longer than five minutes. A debriefing session followed that explained the real purpose of the experiment and all participants were asked if they had suspected that time judgments would be required. No participant reported any suspicion. Participants were then thanked and dismissed.

4.2.2 Results and Discussion

Perceived Task Difficulty

To assess whether the generation task was accompanied by different retrieval experiences, participants' difficulty ratings were submitted to a single factor (cue: present or absent) between-subjects ANOVA. This analysis confirmed that participants found it easier to generate animal names when cue cards were present rather than absent, $F(1,58) = 254.33$, $p < .0001$ (see Table 6 for treatment means).

Duration Estimates

Participants' retrospective duration estimates were converted to seconds and the resultant data were submitted to a single factor (cue: present or absent) between-subjects ANOVA. As expected, this revealed an effect of cue on duration judgments, such that participants believed they had spent more time generating animal names when cue cards were present rather than absent, $F(1,58) = 32.79$, $p < .0001$ (see Table 6 for treatment means). This pattern of findings is consistent with what would be expected if participants used their experienced ease or difficulty of retrieval as a source of information for estimating elapsed time.

Free Recall Performance

The total number of animal names correctly recalled served as a measure of free recall performance. These scores were submitted to a single factor (cue: present or absent) between-subjects ANOVA. This revealed an effect of cue on participants' recall performance, such that more animal names were remembered from the

generation task when cue cards were present rather than absent, $F(1.58) = 43.20$, $p < .0001$ (see Table 6 for treatment means). Thus, as differences in recall performance emerged between the two experimental conditions, the time estimation results are also consistent with the hypothesis that participants used the amount of information stored in memory as a cue to guide their retrospective duration judgments.

Table 6.

Mean Ratings of Duration (s), Task Difficulty, and Free Recall Performance as a Function of Cue (standard deviations in parentheses)

Cue	Duration Estimates	Task Difficulty	Free Recall
Present	67.53 (7.44)	2.43 (0.86)	18.97 (2.17)
Absent	57.63 (5.86)	6.03 (0.89)	15.40 (2.03)

Duration Estimates and Difficulty Ratings

To analyse the relationship between participants' duration estimates and ratings of retrieval difficulty, a correlational analysis was conducted. This revealed that these two variables were correlated, such that duration estimates decreased as the perceived difficulty of retrieval operations increased, $r(58) = -.794$, $p < .001$. As the results satisfied the conditions for testing mediation (Baron & Kenny, 1986), an ANCOVA was performed to establish if the subjective difficulty of retrieval operations mediated the effect of cue on participants' duration estimates. This analysis revealed that when task difficulty ratings were partialled out of the analysis, the effect of cue on duration estimates was reduced, but not eliminated, $F(1,57) = 13.92$, $p < .001$. This finding confirms that the subjective ease or difficulty of prior retrieval operations exerted a mediational influence on participants' judgments of remembered duration. However, this effect was not as pronounced as in the initial experiments in this thesis when memory performance was indexed by free recall.

The results of this experiment replicate and extend the previous findings in many ways. Participants' retrospective duration judgments were influenced by the ease or difficulty they experienced bringing items of information to mind. When the retrieval

task was experienced as subjectively easy (i.e., cued version of the generation task). participants judged that more time had been spent generating the animal names. In contrast, when the retrieval task was deemed to be subjectively difficult (i.e., no-cue version), participants judged that less time had been spent generating the animal names. These differences in judged duration fit well with the hypothesis that participants relied on their prior retrieval experiences as a source of information to compute how much time had elapsed during the task.

Further support for the experience-based hypothesis can be garnered from the results of the other statistical analyses. The correlational analysis revealed that judgments of elapsed time decreased as retrieval operations were perceived to increase in difficulty. In addition, the mediational analysis confirmed that participants' experienced ease or difficulty of retrieval played an influential role in shaping their retrospective duration judgments. However, as in two of the previous studies (Expts. 4 and 5), when task difficulty ratings were partialled out of the analysis, the effect of the independent variable (i.e., cue) on duration estimates was not fully eliminated. Presumably, as before, the mediational analysis failed to completely eliminate this effect as the original effect was so large. Perhaps this is caused by the fact that participants had to deal with a large amount of information during the temporal interval. Taken together, this study extends the previous research as it suggests that experiences of ease or difficultly associated with retrieval operations can serve as useful information for estimating elapsed time, in the same way as experiences associated with encoding operations can function as an informative temporal cue. In addition, as a different clock time and duration judgment scale were used, the generality of the findings is further extended.

There are however some obvious difficulties in interpreting the reported findings as unequivocal support for the experience-based hypothesis. First, unlike the previous studies which measured recall performance (Expts. 1-3), experiential effects on duration judgments emerged in the presence of memory recall differences. The cued version of the animal-generation task (i.e., easy task) led to increased memory for the self-generated items and was judged as longer in duration than the no-cue version of the task (i.e., difficult). Thus, as retrospective duration judgments were predictable from the free-recall data, participants could also have used the amount of information stored in memory to make their assessments of elapsed time (Ornstein, 1969).

Second, as reliance on an experience-based or content-based strategy lead to the same duration judgments being made, it is difficult to ascertain which one is utilised in the decision-making process. Third and finally, Block's (1989a; Block & Reed, 1978) contextual-change hypothesis of remembered duration can also provide an explanation for the observed pattern of time estimation results.

This hypothesis asserts that retrospective duration judgments are based on the remembered amount of change in cognitive context that occurred during the critical interval. In the previous studies, it was unclear how the experimental manipulations (e.g., typeface or accent) would affect the amount of change experienced during the fixed time period. However, advocates of the contextual-change hypothesis might argue that the cue card manipulation in the present experiment caused a difference in what Block (1992) refers to as "environmental context" to be stored in memory in the two experimental conditions. Accordingly, it could be claimed that duration estimates were longer for the cued version of the generation task because the presentation of cue cards caused an increase in this particular aspect of contextual change to be stored in memory during the interval. Although this is a reasonable assumption, the amount of contextual information in memory storage can only be inferred as the contextual-change model fails to incorporate an independent way of establishing the extent of contextual change.

Despite this underlying problem, it is still feasible that differences in the amount of change experienced during the cue and no-cue generation tasks influenced participants' duration estimates rather than differences in experienced retrieval difficulty, or differences in memory for the generated interval items. Unfortunately, as a judgmental strategy based on contextual change leads to the same assessments of elapsed time being made as the other two strategies (experience and content), strong conclusions can not be drawn about which is used as the basis for judgment. Clearly then, more conclusive evidence is needed to show that the subjective ease or difficulty of prior retrieval operations can function as an informative temporal cue in its own right. This raises the question, of course, of how an experiment could be designed that would allow the experience-based account of remembered duration to be empirically distinguished from the traditional memory-based accounts (change and content). This issue will be addressed in the next experiment.

4.3 EXPERIMENT 7: COUNTRY-GENERATION TASK (15 vs. 30)

To disentangle these competing hypotheses (experience vs. change/content), retrospective duration judgments need to be examined in a task context in which they make alternative predictions. Only in so doing, will it be possible to conclusively determine the basis of people's judgments of remembered duration. Such a task context will be created in the present experiment by using an adaptation of the experimental paradigm devised and first used by Schwarz, Bless, et al. (1991).

As in the previous study, a semantic category generation task will be performed during the critical interval. However, on this occasion, the category items to-be-generated are countries of the world. To provide a direct test of the moderating role of prior retrieval experiences, contextual change and informational content on judgments of remembered duration, it is essential that the country-generation task produces differences in these three factors. This will be achieved by varying the number of country names that participants have to generate during the task (see below). Half of the participants will be required to generate out loud the names of 15 countries and the other half will be required to generate out loud the names of 30 countries. Critically, for retrospective duration judgments to be comparable in the two experimental conditions, the generation task has to last for a fixed time period. To fulfil this objective, a metronome will be set up to beep at regular intervals throughout the task. Participants in the 15-generation condition will be instructed to generate a country name on alternate beeps of the metronome, whereas participants in the 30-generation condition will be instructed to generate a country name on every beep of the metronome. This simple procedure ensures that there are large differences between the two experimental conditions in the amount of information that is generated during the task interval, but no differences in the number of beeps that occur, or in the amount of time that elapses during the task. The duration of the task interval to be estimated will be slightly longer than that used in the previous study (1 min 15 s). This will assess the extent to which the reported effects generalise to other objective clock time durations in the second and minute range.

With the task context explained, attention needs to be turned to how varying the number of items that participants have to generate in a fixed interval directly manipulates the subjective demands of memory retrieval, the amount of contextual

change experienced, and the amount of information stored in memory. Each will be considered in turn. First, it was anticipated that the number of country names to be generated (15 vs. 30) would moderate the retrieval experience (easy vs. difficult respectively). That is, participants would experience more difficulty generating 30 rather than 15 country names. Second, it can reasonably be assumed that in the absence of any other environmental changes between the two experimental conditions (e.g., the same testing room, experimenter, equipment, number of beeps of the metronome, lighting), the number of items to be self-generated during the critical interval would provide a salient source of contextual change. Thus, it follows that more contextual change would be experienced and stored in memory after generating 30 rather than 15 country names. Third, self-generating these items would make them highly accessible in memory and so it logically follows that more information would be stored in memory after generating 30 rather than 15 country names. This assumption will be checked by measuring participants' memory for the generated interval items by means of a free recall test.

By examining retrospective duration judgments in this task context, it becomes possible to empirically distinguish the experience-based hypothesis and the traditional memory-based hypotheses of remembered duration as they provide alternative predictions. First, consider retrospective duration judgments from the perspective of the experience-based hypothesis. According to this account, duration estimates should increase as the perceived difficulty of retrieval operations decrease. Thus, provided that participants find it relatively easy to retrieve the names of 15 countries from memory and considerably more difficult to retrieve 30 of these items, then duration estimates should be longer for the 15- rather than the 30-generation task. Now consider retrospective duration judgments from the perspective of each of the traditional memory-based models. According to the change-based hypothesis, duration estimates should increase as a function of the number of contextual changes that occur in the critical interval (Block, 1989a; Block & Reed, 1978). This hypothesis therefore predicts that duration estimates should be longer for the 30- rather than the 15-generation task because more contextual change would be stored in memory and remembered at the time of judgment. According to the content-based hypothesis, duration estimates should increase with the number of items of information stored in memory during the critical interval (Ornstein, 1969). This hypothesis therefore predicts that duration estimates should be longer for the 30-

rather than the 15-generation task because more information would be stored in memory.

In sum, two alternative predictions are specified. If people rely on the amount of information stored in memory to estimate elapsed time (i.e., contextual change or generated interval items), then they will report that more time was spent generating the country names in the 30- rather than in the 15-generation condition. However, if people use their prior retrieval experiences as a basis for judgment, then this pattern should reverse. That is, people will report that less time was spent generating the country names in the 30- rather than in the 15-generation condition.

4.3.1 Method

Participants and Design

Seventy–one undergraduates from the University of Bristol agreed to participate in the experiment and received either a chocolate bar or course credit for taking part. All participants were native speakers of English and had normal hearing. The study had a single factor (countries generated: 15 or 30) between-subjects design. In order to test the competing explanations of retrospective duration estimation, it was imperative that each participant generated the required number of items during the task interval. On this basis, 11 participants from the 30-generation condition were excluded from the data set as they failed to generate the required number of items. This left 60 participants (30 men and 30 women) in the final analyses with an equal number of men and women randomly assigned to each of the experimental conditions.

Procedure and Materials

Participants arrived at the laboratory individually and were informed that the study was an investigation into semantic memory. Participants' attention was then drawn to a metronome which was located on a table near to where the participants were asked to sit. The dial on the side of the metronome was not visible to participants. It was explained that the metronome would beep when it was turned on. Unbeknown to the participants, the metronome was set to beep every 2.5 s. Participants in the 30-generation (difficult) condition were informed that their task was to generate out loud

an item from a particular category to each beep of the metronome. No information was given regarding the number of items that would have to be generated during the task. Participants in the 15-generation (easy) condition were told the same except that item generation was required on alternate beeps of the metronome. The category of items chosen for the generation task was countries of the world. However, to prevent participants from thinking of relevant examples prior to the start of the generation task, the category was announced just before the metronome was turned on.

To ensure that participants knew what was meant by the term "a particular category" and to check that they fully understood the task, an example was given. The experimenter gave the following instructions to participants in the 30-generation condition:

> For example, if the category was food, then you would have to say out loud a food item every time you hear a beep. For the first beep, you could say 'cheese', for the second beep, 'apple', and so on. Food is not the category chosen for the task. You will only be told what the category is just before the metronome is turned on.

The instructions were adjusted slightly for participants in the 15-generation condition:

> For example, if the category was food, then you would have to say out loud a food item on the second beep and then on alternate beeps after that. So for the first beep, you would say nothing, for the second beep you could say 'cheese', for the third beep you would say nothing, for the fourth beep, 'apple', and so on. Food is not the category chosen for the task. You will only be told what the category is just before the metronome is turned on.

Once these instructions were understood, participants were told that the generation task would begin when the first beep was heard and would finish when the experimenter said "stop". This ensured that the task interval (i.e., to-be-assessed duration) was clearly delimited for the participants. The experimenter then announced that the category was "countries of the world" and turned on the

metronome. During the task interval the metronome beeped 30 times, once every 2.5 s. Participants in the 30-generation condition generated a country name every time they heard a beep (1/2.5 s), whereas participants in the 15-generation condition generated a country name on alternate beeps (1/5 s). In this way, the number of items generated during the task interval was different in the two conditions (30 vs. 15), but the number of beeps that occurred (30) and the duration of the task (1 min 15 s) were held constant. The experimenter noted down the names of the countries generated by each participant on a sheet of paper so that the number correctly recalled later in a free recall test could be measured. This procedure also alerted the experimenter as to when the last beep would sound so the metronome could be turned off and the word 'stop' could be announced to delimit the end of the generation task. Following the generation task, participants performed a distractor activity in which they were required to circle all the two-digit numbers in a short booklet that were divisible by 7. Participants were not informed about the length of time they would be given for this task. A 5 min period was accurately timed using a concealed stopwatch and then the booklets were collected.

Next, participants were given a short questionnaire consisting of two questions that related to the country-generation task they had performed earlier in the experiment. The order of presentation of the questions was counterbalanced across the two experimental conditions. Participants were asked to answer the questions in the order presented and were encouraged to be as accurate as possible in their responses. One question required participants to estimate how much time they believed had elapsed during the generation task. The question sheet expressed clearly that the interval of time to-be-estimated began when the first beep was heard and ended when the experimenter said "stop". A duration judgment scale was provided ranging from 30 s to 1 min 50 s with intervals of 10 s. Ticks to mark the 1 s intervals were also clearly indicated along the length of the scale. Participants were asked to use the scale to mark off their subjective impression of elapsed time to the nearest second. The other question required participants to rate on a 9-point scale how much difficulty they had experienced generating the countries with 1 representing '*very easy*' and 9 representing '*very difficult*'. Finally, participants were given a free recall test in which they were asked to recall and write down the names of all the countries they remembered generating in the space provided on the questionnaire. Participants were told that they could take as much time as they required on this task, but no participant

took any longer than five minutes. Participants were then debriefed as to the real purpose of the experiment, thanked for their assistance, and dismissed. Once again, none of the participants had suspected that they would be required to estimate how much time had elapsed during the generation task.

4.3.2 Results and Discussion

Perceived Task Difficulty

To assess whether the generation task was accompanied by different retrieval experiences, participants' difficulty ratings were submitted to a single factor (countries generated: 15 or 30) between-subjects ANOVA. As expected, manipulating the number of countries generated had the intended effect on perceived task difficulty, $F(1,58) = 42.77$, $p < .0001$. Participants considered the task to be easier when they had generated the names of 15 rather than 30 countries (see Table 7 for treatment means).

Duration Estimates

Participants' retrospective duration estimates were converted to seconds and the resultant data were submitted to a single factor (countries generated: 15 or 30) between-subjects ANOVA. This revealed an effect of number of countries generated on duration judgments, such that participants believed they had spent more time generating 15 rather than 30 country names, $F(1,58) = 8.31$, $p < .006$ (see Table 7 for treatment means). This pattern of time estimation results is consistent with what would be expected if participants used their prior retrieval experiences as a cue to guide their retrospective duration judgments rather than the amount of contextual change stored in memory. Thus, the experience-based hypothesis of remembered duration rather than the change-based hypothesis is needed to explain these findings.

Free Recall Performance

The total number of country names correctly recalled served as a measure of participants' free recall performance. A single factor (countries generated: 15 or 30) between-subjects ANOVA revealed an effect of number of countries generated on recall performance, $F(1,58) = 161.67$, $p < .0001$. Participants remembered more

countries names when they had generated 30 rather than 15 of these items (see Table 7 for treatment means).

Table 7.

Mean Ratings of Duration (s), Task Difficulty, and Free Recall Performance as a Function of Number of Countries Generated (standard deviations in parentheses)

Number Generated	Duration Estimates	Task Difficulty	Free Recall
15	80.70 (8.99)	1.70 (0.88)	11.60 (1.59)
30	72.63 (12.41)	5.13 (2.74)	16.93 (1.66)

The observed pattern of time estimation results also present problems for the content-based hypothesis of retrospective timing. The task that led to increased memory for the generated interval items was actually judged as shorter in duration (i.e., 30 countries) than the task that led to decreased memory performance (i.e., 15 countries). Thus, as retrospective duration judgments were inversely rather than directly related to the number of items remembered from the judged interval, participants could not have used the amount of information stored in memory as a cue to compute elapsed time. Rather it seems that participants based their temporal judgments on their experienced ease or difficulty of retrieval. When the retrieval task was deemed to be subjectively difficult (i.e., 30 countries), participants judged that less time had been spent generating the country names compared to when the retrieval task was deemed to be subjectively easy (i.e., 15 countries).

Duration Estimates and Difficulty Ratings

Further evidence for this conclusion was obtained by a correlational analysis. Specifically, participants' duration estimates decreased as their reported difficulty of retrieving the country names increased, $r(58) = -.726$, $p < .001$. As the results met with the conditions required for testing mediation (Baron & Kenny, 1986), an ANOVA was performed on the data to establish if the subjective difficulty of retrieval operations mediated the effect of number of countries generated on participants' duration estimates. This analysis revealed that when task difficulty

ratings were partialled out of the analysis, the effect of number of countries generated on duration estimates was reduced to a marginal level of significance, $F(1,57) = 3.15$, $p < .09$. This finding therefore confirms that the subjective ease or difficulty of prior retrieval operations mediated participants' retrospective duration judgments.

In the previous study, it was impossible to determine the basis of people's judgments of remembered duration as the time estimation results could be explained by the experience-based, change-based, and content-based hypotheses. The main purpose of the current experiment was therefore to disentangle the experience-based account of retrospective timing from the traditional memory-based accounts (change and content) by examining duration judgments in a task context in which they provide alternative predictions. This objective was successfully achieved. Fruitfully for the experience-based hypothesis, the results obtained reflect unfavourably on these alternative accounts of remembered duration and provide more conclusive evidence for the role of subjective retrieval experiences in the construction of retrospective duration judgments. Furthermore, as a different clock time duration was assessed than in the previous study and the duration judgment scale was different from that used in Experiments 1-5, the generality of experiential influences on judgments of elapsed time is further extended.

The results of this experiment show that the task which required participants to generate more information during the critical interval (i.e., 30 countries) was judged as shorter in duration than the task which required participants to generate less information (i.e., 15 countries). These findings are difficult to reconcile using a change-based hypothesis of retrospective timing (cf. Block, 1989a; Block & Reed, 1978). Presumably generating more items of information during the to-be-assessed duration would cause an increase in the number of contextual changes stored in memory and remembered at the time of judgment. Thus, according to this account the 30-generation task should have been judged as longer in duration than the 15-generation task. As this was not the case, participants could not have based their judgments of elapsed time on the amount of contextual change stored in memory. The content-based hypothesis faces similar problems. Generating more items of information during the critical interval caused an increase in the number of generated items that were stored in memory (as reflected by the recall scores). Hence, if

duration judgments had been based on the amount of information in memory storage, then the 30-generation task should have been judged as longer than the 15-generation task. The failure to confirm this straightforward prediction also casts doubt on the content-based account of retrospective duration estimation (cf. Ornstein, 1969).

Clearly, the experience-based hypothesis of remembered duration is needed to explain the observed results. The number of items to be generated during the critical interval was sufficient for participants to have different retrieval experiences. Participants found it considerably difficult to retrieve 30 country names from memory and relatively easy to retrieve 15 of these items from memory. When the retrospective duration judgment was unexpectedly requested, it appears that participants used their assessment of how easy or difficult it was for them to bring these items of information to mind as a cue to compute how much time had elapsed during the task. Participants who had experienced difficulty bringing 30 countries to mind interpreted this to mean that they must not have been given much time to perform the task. Thus, short retrospective duration judgments were provided by these participants. In contrast, participants who had experienced ease bringing 15 countries to mind interpreted this mean that they were given a sufficient amount of time to perform the task in a satisfactory manner. This was reflected in their longer judgments of elapsed time. The results of the mediational analysis provide direct evidence for this experience-based account of retrospective timing. Thus, it can be concluded that the subjective ease or difficulty of prior retrieval operations influenced people's judgments of remembered duration rather than memory for contextual change or for the interval items per se.

4.4 EXPERIMENT 8: LETTER 'S' WORD-GENERATION TASK (13 vs. 26)

Given that the findings of Experiment 7 provide strong support for the experience-based hypothesis and fail to corroborate the traditional memory-based accounts of retrospective duration estimation, a conceptual replication would be welcome to determine the generality of these ease of retrieval effects. The present experiment will provide this replication. It will also extend the previous study by examining people's retrospective duration judgments in a different task context.

As before, participants will be given the task of generating out loud items of information during the critical interval. However, as a modification to the previous experiment, a letter naming task will be performed rather than a semantic category naming task. The items to-be-generated are words beginning with the letter 's'. As in the previous study, the difficulty of retrieval operations, the amount of contextual change and informational content stored in memory will be manipulated by varying the number of items that participants have to generate during the task. Half of the participants will be required to generate 13 s-words and the other half will be required to generate 26 s-words. To ensure that participants experience the same objective clock time duration during the generation task, a metronome will again be set up to beep at regular intervals throughout the task. Participants in the 13-generation condition will be instructed to generate a word beginning with the letter 's' on alternate beeps of the metronome, whereas participants in the 26-generation condition will be instructed to generate one of these words on every beep of the metronome. A final modification to the methodology involves the duration of the task interval to be estimated. In the current experiment, the generation task will last for a slightly shorter duration than in the previous study (1 min 05 s). This will assess the extent to which the reported effects generalise to other temporal durations in the second and minute range.

The predictions deriving from the experience-based, change-based, and content-based hypotheses were as in the previous experiment. If people rely on their experienced ease or difficulty of retrieval to estimate elapsed time, then they will report that less time was spent generating the s-words in the 26-generation condition (difficult task)) rather than in the 13-generation condition (easy task). In contrast, if people rely on the amount of information stored in memory (i.e., contextual change or generated interval items), then they will report that more time was spent generating the s-words in the 26- rather than in the 13-generation condition.

4.4.1 Method

Participants and Design

Seventy-five undergraduates from the University of Bristol participated in the experiment in partial fulfilment of a course requirement. All participants were native speakers of English and had normal hearing. The study had a single factor (s-words

generated: 13 or 26) between-subjects design. 15 participants in the 26-generation condition were omitted from the data set as they failed to generate the required number of items during the task interval. This left 60 participants (30 men and 30 women) in the final statistical analyses with an equal number of men and women randomly assigned to each of the experimental conditions.

Procedure and Materials

Participants arrived at the laboratory individually and were informed that the study was an investigation into semantic memory. The experiment was basically a replication of the previous study, but with a few modifications. On this occasion, the to-be-generated items were words beginning with the letter 's' (excluding proper nouns, numbers, and the same word with a different suffix). As in the previous study, to prevent participants from thinking of relevant examples prior to the start of the generation task the exact nature of the items to be generated was only announced just before the metronome was turned on. However, due to the different nature of the task (i.e., letter vs. category naming), the instructions and the example given to participants at the beginning of the experiment had to be adjusted slightly. Participants in the 26-generation condition were informed that their task was to generate out loud a word beginning with a certain letter to each beep of the metronome. Participants in the 13-generation condition were told the same except that word generation was required on alternate beeps of the metronome. The example given was words beginning with the letter 'a' and the experimenter emphasised that proper nouns, numbers, and the same word with a different suffix could not be used in the generation task.

During the task interval, the metronome beeped 26 times at 2.5 s intervals. Participants in the 26-generation condition generated an s-word on every beep of the metronome (1/2.5 s), whereas participants in the 13-generation condition generated an s-word on alternate beeps of the metronome (1/5 s). In this way, the amount of information generated during the task interval was different in the two conditions (26 vs. 13), but the number of beeps that occurred (26) and the total duration of the task (1 min 05 s) were held constant. Apart from these necessary modifications, the procedure was as in Experiment 7. The dependent measures were also the same with the exception of a slight adjustment to the duration judgment scale. The scale ranged from 45 s to 1 min 25 s with intervals of 5 s. Ticks to mark the 1 s intervals were also

clearly indicated along its length. On completion of the experimental tasks, participants were debriefed, thanked, and dismissed. Once again, none of the participants had suspected that the experiment was concerned with time estimation so their duration judgments were formed in retrospect as required.

4.4.2 Results and Discussion

Perceived Task Difficulty

To assess the retrieval experiences associated with the generation task, a single factor (s-words generated: 13 or 26) between-subjects ANOVA was performed on participants' difficulty ratings. This analysis confirmed that participants' experiences of retrieval difficulty varied as a function of the number of s-words generated, such that the task was considered to be easier when they had generated 13 rather than 26 s-words, $F(1,58) = 240.94$, $p < .0001$ (see Table 8 for treatment means).

Duration Estimates

Participants' retrospective duration estimates were converted to seconds and the resultant data were submitted to a single factor (s-words generated: 13 or 26) between-subjects ANOVA. As expected, this revealed an effect of number of s-words generated on participants' duration judgments, such that more time was believed to have been spent generating 13 rather than 26 s-words, $F(1,58) = 15.05$, $p < .0003$ (see Table 8 for treatment means). Once again, participants' estimates of elapsed time varied as a function of their experienced ease or difficulty of retrieval rather than the amount of contextual change stored in memory. Thus, the experience-based hypothesis of remembered duration rather than the change-based hypothesis is needed to explain this pattern of findings.

Free Recall Performance

Total correct recall scores were submitted to a single factor (s-words generated: 13 or 26) between-subjects ANOVA. This analysis revealed an effect of number of s-words generated on participants' recall performance, such that more s-words were remembered when they had generated 26 rather than 13 of these items, $F(1,58) = 34.53$, $p < .0001$ (see Table 8 for treatment means).

Table 8.

Mean Ratings of Duration (s), Task Difficulty, and Free Recall Performance as a Function of Number of S-words Generated (standard deviations in parentheses)

Number Generated	Duration Estimates	Task Difficulty	Free Recall
13	64.80 (6.26)	2.50 (0.73)	6.70 (1.34)
26	58.63 (6.05)	5.60 (0.81)	8.73 (1.34)

The content-based hypothesis of retrospective timing can also not explain the observed findings. The task which required the generation of 26 rather than 13 s-words produced better recall performance and shorter retrospective duration judgments. Finding an inverse rather than a direct relationship between participants' judgments of remembered duration and their memory for the interval items can be taken as evidence against this hypothesis. Clearly, time estimation in the present context was not mediated by the amount of information stored in memory. Thus as in the previous study, the present findings are best explained by the experience-based hypothesis. Participants seemed to use their experiences of ease or difficulty associated with memory retrieval as input for their retrospective duration judgments.

Duration Estimates and Difficulty Ratings

This conclusion is further supported by the results of a correlational analysis. Specifically, participants' duration estimates decreased as their reported difficulty of retrieving the s-words increased, $r(58) = -.519$, $p < .001$. As the results satisfied the conditions for testing mediation (Baron & Kenny, 1986), an ANOVA was performed on the data. This analysis revealed that when task difficulty ratings were partialled out of the analysis, the effect of number of s-words generated on duration estimates was completely eliminated, $F(1,57) < 1$, *ns*. Thus, the subjective ease or difficulty of prior retrieval operations mediated participants' judgments of remembered duration.

The results of this experiment therefore closely replicate and extend the findings obtained in the previous study. Participants' retrospective duration judgments were influenced by the ease or difficulty they experienced bringing items of information to

mind. When the task of retrieving information was experienced as difficult and demanding (i.e., 26 s-words), participants believed that they had spent less time performing the activity. Conversely, when the task of retrieving information was considered to be relatively easy (i.e., 13 s-words), participants believed that they had spent more time performing the activity. Hence, these findings reinforce the notion that people pay attention to their prior retrieval experiences and use the information they provide to guide their judgments of elapsed time. This experience-based account of retrospective timing is confirmed by the results of the mediational analysis. In addition, the observed results also extend the previous study as the generated items were of a different nature and the duration of the task was of a different length, but comparable effects emerged. This provides supporting evidence that ease of retrieval effects generalise across different task contexts and different objective clock time durations in the second and minute range.

Theoretically, these results present difficulties for both Block's (1989a; Block & Reed, 1978) change-based account and Ornstein's (1969) content-based account of retrospective duration estimation. Presumably a greater number of contextual changes would be experienced and stored in memory as the subjectively difficult task of retrieving 26 s-words was performed during the critical interval. Moreover, the free recall scores show that this task led to increased memory for the self-generated interval items. Accordingly, if duration judgments had been based on the amount of information stored in memory (i.e., in terms of contextual information or generated information), then the subjectively difficult retrieval task (i.e., 26 s-words) should have been judged as longer in duration than the subjectively easy retrieval task (i.e., 13 s-words). As the exact opposite pattern was found, the inference can be made that the contents of memory played no role in shaping people's judgments of remembered duration. Rather as ease of retrieval effects emerged in the absence of these memory content influences, it can be strongly concluded that people's retrospective duration judgments were driven by their experiences of ease or difficulty associated with prior retrieval operations.

4.5 CHAPTER DISCUSSION

In Experiment 6, strong conclusions could not be drawn about whether people relied on an experience-based, change-based, or content-based judgmental strategy for

retrospectively estimating the duration of the generation task. The obtained time estimation results fitted the pattern expected by any of these three strategies. The main objective of Experiment 7 was therefore to determine more conclusively the basis of people's judgments of remembered duration. This was achieved by using an experimental paradigm (i.e., varying the number of items to-be-generated during a fixed time period) that afforded a direct test between the experience-based account of retrospective timing and the traditional memory-based accounts (i.e., change and content) as they provided alternative predictions. In so doing, convincing evidence was obtained that subjective experiences of ease or difficulty evoked by memory retrieval operations serve as an important determinant of people's retrospective duration judgments. By conducting a conceptual replication of this study with some added modifications (Experiment 8), this contention was substantiated and extended further. Subjective ease of retrieval effects were found across different kinds of generation tasks and different temporal durations in the second and minute range. In addition, these experiential influences emerged regardless of using a different duration judgment scale from that employed in the earlier experiments where comparable effects were observed.

In demonstrating this, the traditional memory-based accounts of how people form an impression of elapsed time are called in question; at least when retrospective duration judgments are formed in task contexts similar to those used here. In all three of the experiments reported in this chapter, the generation task performed during the to-be-judged interval provided the time estimator with three possible bases for judgment – the experienced ease or difficulty of retrieval, the amount of contextual change stored in memory, and the number of generated interval items stored in memory. In Experiments 7 and 8, ease of retrieval effects emerged in the absence of contextual change or informational content influences. This seems to strongly suggest that in situations of this kind, experiential information serves as a more revealing judgment-cue to infer elapsed time than these other sources of information. It must therefore be conceded that Block's (1989a, 1990; Block & Reed, 1978) contextual-change hypothesis and Ornstein's (1969) storage-size hypothesis can not predict people's judgments of remembered duration in all circumstances.

Of course, advocates of the former account could argue that the time estimation results in Experiments 7 and 8 only appear problematic for the change model because

these studies have misconstrued the nature of contextual changes that mediate judgments of remembered duration. The problem with this defence is that there is no precise specification of contextual change; in fact, to the contrary it is rather unconstrained. Until there is an agreed-upon-measure of contextual change, this hypothesis of retrospective duration estimation can not be directly tested. However, as this is one of the dominant accounts in the retrospective timing literature, a manipulation of contextual change had to be attempted. The reasonable assumption was made that the number of items self-generated during a fixed interval provides an index of the amount of contextual change that is experienced and stored in memory during that interval. It is unclear why intervals filled with more items would not be filled with more perceived changes. Thus, it can be strongly assumed that contextual influences were in operation as the generation tasks were performed, but they failed to directly influence people's judgments of elapsed time.

One other issue from the retrospective temporal estimation literature merits brief comment. In retrospective temporal tasks, it is imperative that participants only acquire a temporal motive when they are given the duration judgment instructions after the critical interval has elapsed. If participants were aware that the experiment was concerned with time estimation, then they would undoubtedly pay attention to the passage of time during the interval and their subsequent duration judgment would be prospective rather than retrospective in nature. Zakay (1990) pointed out that one factor which might attract participants' attention to the passage of time and cause them to suspect that they are involved in a time experiment is the presence of environmental tempo, such as a metronome beat. While this is almost certainly the case when participants' only task is to listen to the beeps of the metronome during the to-be-judged interval, the same is not true when the beeps form an integral part of the task. In all three of the present experiments, participants were asked if they had suspected that they would be asked to estimate the duration of the generation task. None of the participants reported any suspicion, hence their duration judgments were formed in retrospect as required.

Taken together, the studies in this chapter provide strong evidence that subjective experiences of ease or difficulty associated with prior retrieval operations guide people's judgments of remembered duration. As such, this research corroborates related work in social cognition which has shown that retrieval experiences can

function as a highly informative cue in the formation of social judgment (e.g., Schwarz, 1998). Moreover, the present research extends previous work of this kind in two important ways. First, although ease of retrieval effects have been consistently demonstrated for judgments in subjective domains (e.g., Schwarz, Bless, et al., 1991; Rothman & Schwarz, 1998; Wänke et al., 1996), the current studies show that comparable effects emerge for a judgment that is more objective in nature. Second, unlike other research in this domain, the information provided in the retrieval task did not relate in any way to the judgment under investigation. The fact that experiential influences still impacted on people's judgments of duration in this context demonstrates the generality of ease of retrieval effects. In addition, it suggests that these effects can emerge regardless of whether or not the information retrieved from memory is relevant to the subsequent judgment (i.e., subjective and objective judgments respectively).

Thus, to conclude, the research reported to date provides compelling evidence that subjective experiences of ease or difficulty associated with both memory encoding (Expts. 1-5) and memory retrieval (Expts. 6-8) play an important role in retrospective temporal estimation. Put another way, people use subjective cues that relate to the experiential concomitants of prior processing operations to guide their judgments of remembered duration; at least for temporal durations in the second and minute range and in task contexts similar to those used here. Would however effects of the sort reported thus far emerge in more realistic (e.g., dynamic) task contexts? This challenging question provided the motivation for the final experiment in this thesis.

CHAPTER 5

EXPERIMENT 9

5.1 INTRODUCTION

Thus far the relationship between the subjective ease or difficulty of prior processing operations and judgments of remembered duration has been demonstrated in traditional laboratory-based experiments. Experiential effects were obtained in task contexts in which participants studied a list of written words (Expts. 1-3), listened to a tape-recorded passage (Expts. 4-5), and generated items of information (Expts. 6-8) during the judged interval. The question remains, however, whether these effects would extend from laboratory settings to more dynamic task environments. Investigating such a phenomenon in the real world would be tricky. Controlling the necessary experimental factors in such an environment, particularly the duration of the task interval to-be-estimated, would be difficult, if not impossible. New and exciting advancements in digital technology, however, provide a potential solution to this problem.

Using immersive virtual environment technology (IVET), it is now possible to create and immerse people within dynamic and compelling three-dimensional virtual environments that mimic real world situations. Although this powerful medium is more commonly known as virtual reality in the entertainment industry, scientists prefer to use the term (immersive) virtual environments due to the contradictory nature of the former terminology (i.e., how can something be both virtual and real). Blascovich, Loomis, Beall, Swinth, Hoyt, and Bailenson (2002) define a '*virtual environment*':

> As synthetic sensory information that leads to perceptions of environments and their contents as if they were not synthetic (p. 105).

This synthetic information is primarily visual, but any single sensory modality, or a combination, can contribute to the perception of a virtual environment. Basically, virtual environments can be synthetic representations of anything in the physical world (e.g., theme park) or from the world of make-believe (e.g., flying carpet). An

'*immersive virtual environment*' is described by the same group of researchers (Blascovich et al., 2002) as:

> One that perceptually surrounds an individual. Immersion in such an environment is characterised as a psychological state in which the individual perceives himself or herself to be enveloped by, included in, and interacting with an environment that provides a continuous stream of stimuli (p. 105).

IVET thus provides researchers with a unique and valuable tool for conducting more ecologically realistic experiments than would ever be possible in the traditional laboratory. Moreover, it allows researchers to maintain exceptional control over characteristics of the experimental environment, levels of control that are not possible in the physical world. Simply stated, IVET can create the illusion of the real world in a controlled experimental setting.

For these reasons, it was anticipated that IVET would provide a useful forum to investigate whether the subjective ease or difficulty of prior processing operations also guides people's retrospective duration judgments in task contexts that are more dynamic than those previously studied. Luckily for me, this research was made possible by the Economic and Social Research Council who funded an overseas research visit to the University of California, Santa Barbara, home to one of the leading Virtual Environment Research Centres in the world. Although only recently established in 1998, the 'Research Center for Virtual Environments and Behavior' (RECVEB) has already conducted pioneering research in multi-disciplinary areas of psychology (e.g., social, vision, spatial cognition, education) making clever use of IVET (Co-Directors: James Blascovich and Jack Loomis). It was here that I made use of the latest technology (with the technical and methodological support of the research staff) to create my very own virtual environment.

Extending on the previous laboratory-based studies, the experiment in this chapter will test the experience-based hypothesis of retrospective timing further by examining people's judgments of remembered duration after they have performed an easy or a difficult memory task in an immersive virtual environment. In this way, subjective experiences associated with memory encoding rather than memory

retrieval will be manipulated. Obviously, in such an experimental setting, a task that requires participants to visually encode information from the virtual environment makes their immersive sensory experience far more compelling than a task that requires the retrieval of information from memory. Specifically then, when participants are immersed within a virtual environment in which they are required to commit items to memory, will they rely on their experienced ease or difficulty of encoding as a cue to compute how much time has elapsed during the task? A successful replication of the results from the previous studies that utilised this ease of encoding paradigm (Expts. 1-5) would demonstrate the robustness of experiential effects across different experimental settings (i.e., laboratory and virtual environments). As in all the experiments to date, the experience-based hypothesis will be competitively tested against Ornstein's (1969) storage-size hypothesis of remembered duration. However, before the details of the experiment can be discussed, it is necessary to explain the technology that is used to create a virtual environment and to consider how the IVET enables participants to become immersed within a virtual world (for a more detailed and technical description, see Blascovich et al., 2002; Loomis, Blascovich, & Beall, 1999).

5.1.1 Overview of Technology

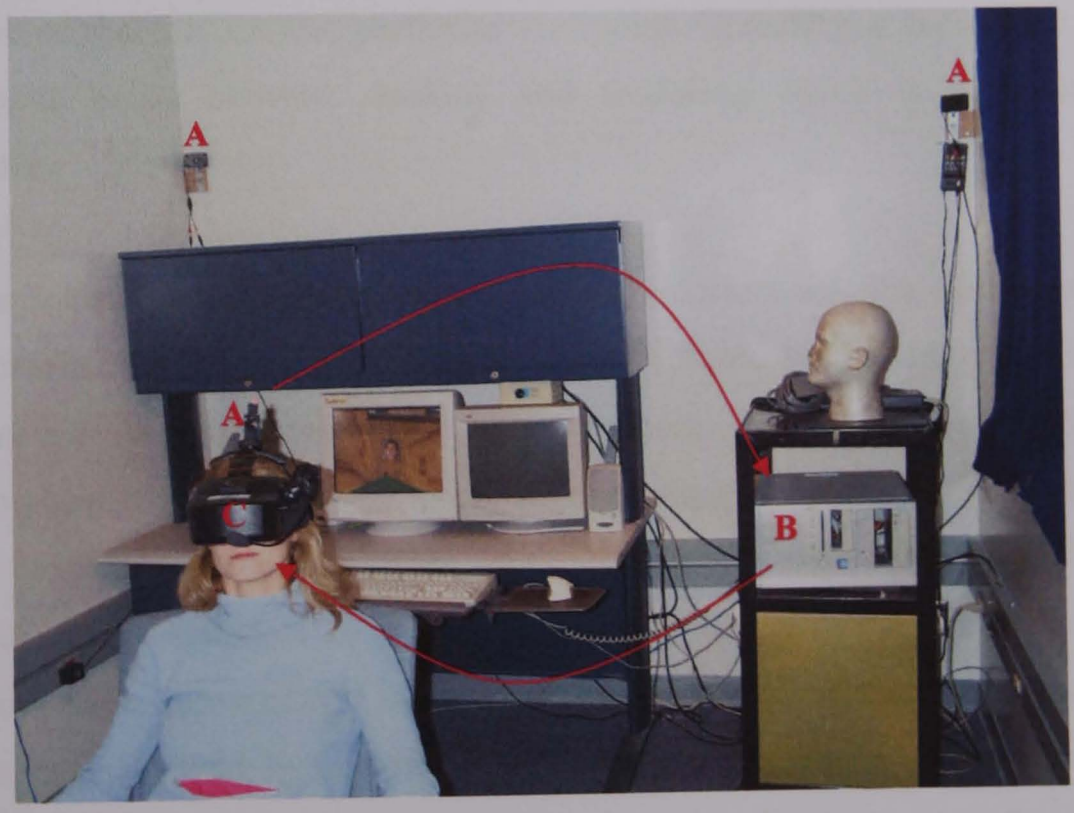
Virtual environments are created using specialised multimedia development software programs (i.e., a three-dimensional world construction toolkit). Like physical environments, virtual ones can appear to have fixed dimensions (e.g., the inside of a casino) or unlimited dimensions (e.g. a mountain top view). To create such a virtual environment, high-level computer languages are used to construct a three-dimensional model of a superordinate space (e.g., a room), with the same principles applying to the contents within it (e.g., tables, picture frames, people). The object models can be positioned anywhere within the superordinate space. These models do not have to be visual, but can be based on sound and with more difficulty, smell or touch. This three-dimensional information makes up a database, which is stored digitally and represents the virtual environment itself. Once the basic model has been created, various surface patterns can be added such as colours, textures, photographs, and translucencies to make the environment and the objects appear realistic. Light sources to illuminate the virtual world must also be added, but the physical laws of nature (i.e., gravity and magnetic field) are optional depending on whether the virtual

environment is earthlike or not. The objects within the virtual environment need not be stationary; they can be programmed to move around, react naturally to the forces of nature, and interact with other objects.

Now consider the technology that is used to immerse participants within the virtual environment. Several IVET systems have been created for scientists to utilise, but the one described here was developed by Andrew Beall at the Research Center for Virtual Environments and Behavior (RECVEB) at the University of California, Santa Barbara. Simply stated, compelling immersive virtual environments are derived from the careful integration of the aforementioned software and hardware. The hardware includes three major components- display devices, tracking systems, and computers. Figure 1 depicts the IVET system at the RECVEB.

Figure 1.

The IVET System at the RECVEB, University of California, Santa Barbara



A – Tracking System, B – Rendering Computer, C – Head Mounted Display (HMD)

Participants wear a head mounted display (C) that includes a position and orientation tracking system (A). This system comprises three small tracking devices. An LED is tracked by an external video-based system (i.e., cameras in the corners of the physical room) to determine the participant's overall body position in three

dimensions in the physical room where the immersive virtual experience is taking place. An inertial device tracks the orientation of the participant's head in three dimensions and an optical device tracks the participant's eye-movements. The resultant data from the position and orientation tracking system is then sent to the rendering computer (B) which identifies and selects the appropriate visual information from the three-dimensional graphics database of the virtual environment. This updated visual information is then rendered back to the participant via the stereoscopic video displays in the head mounted display (C) which allows a three-dimensional view of the virtual environment. This completes the cycle of information transfer, but the process of tracking and rendering continues repeatedly until the immersive virtual experience is over. Undoubtedly, the most important factor that determines the overall effectiveness of the immersive virtual experience is the time taken for the position and orientation tracking information to be updated and rendered back to the display of the headset, or more technically, the lag. For example, when a participant's head moves up or down to view the virtual ceiling or floor in the virtual environment, the computer must rapidly provide new information so that he or she can see that particular viewpoint. Generally, a lag of less than 40 milliseconds exists between tracking and rendering which is undetectable to participants.

When participants are immersed within a virtual environment, this whole technology system creates the illusion that they are in a different world altogether from the laboratory entered only moments ago. Participants no longer see anything in the real world, because their senses are deceived by sensory input from the illusionary physical environment that surrounds them. This sensory experience is made all the more real for participants as digital immersive virtual environments allow for exploration of the surroundings. Participants can move around freely in the same way as in the physical world, by walking, running, jumping, and so on. Researchers at the RECVEB believe this significantly adds to the participant's overall immersive experience in the virtual environment (Blascovich, 2002). Moreover, as participants move around they receive kinesthetic and vestibular feedback cues that work in harmony with their experiences in the virtual environment which increases their belief that they are present in the simulated environment (i.e., their sense of "personal presence"; Heeter, 1992).

In addition, as the immersive virtual environment and the objects within it have the same size, appearance, and behaviour as their counterparts in the physical world, the illusion of a real and natural environment is created. These factors contribute to the participant's sense of "environmental presence" (Heeter, 1992). In this way, both personal and environmental presence play an important role in creating a compelling immersive sensory experience for participants. In sum, IVET can produce dynamic, engaging, and compelling experimental settings that mimic real life situations within the confines of the laboratory. It is therefore not surprising that psychologists from many disciplines have been quick to utilise this exciting medium as a tool for research purposes (see Blascovich et al., 2002; Loomis et al., 1999; for reviews).

5.2 EXPERIMENT 9: IMMERSIVE VIRTUAL PHOTOGRAPHIC GALLERY FACE-MEMORY TASK (VISUAL NOISE ABSENT vs. PRESENT)

Making use of the flexible processing environments that can be created using IVET, a virtual photographic gallery was designed and constructed for the present experiment. Although researchers conducting virtual environment-based experiments can let their imaginations run riot, on this occasion, the environment created was inspired by real life events. This was of critical importance to the present research so that retrospective duration estimates could be obtained for a situation that is similar to one in which people estimate elapsed time in everyday life.

Thus, in the current study, participants wearing a head mounted display (HMD) will be immersed within a virtual room that resembles a photographic gallery. From a seated position in the physical room, participants will take a virtual journey through the gallery on a moving walkway for a fixed duration. That is, despite being stationary, participants will have the visual sensation of moving forward through the gallery. Undoubtedly, this will increase participants' engagement with the experimental situation. Throughout this journey, participants will sequentially see 20 photographic colour portraits of people's faces suspended from the centre of the ceiling. Participants will be given the task of carefully inspecting and memorising these faces for a subsequent memory test. As in Experiments 4 and 5, this test will assess recognition memory. Recognition accuracy will serve as a measure of the amount of information stored in memory during the to-be-judged interval and thus

will provide a direct test of Ornstein's (1969) storage-size hypothesis of retrospective timing.

To investigate the moderating role of prior encoding experiences on judgments of remembered duration, it is essential that the memory task places differential demands on the encoding process (i.e., easy vs. difficult). As in the previous ease of encoding experiments (Expts. 1-5), this will be achieved independently from the informational content that occurs during the critical interval. In the present context, the subjective demands of memory encoding will be manipulated by varying the manner in which the to-be-remembered items are presented to participants. Specifically, half of the participants will be required to memorise 20 faces that are degraded with visual noise, whereas the other participants will be required to memorise the same 20 faces without any visual noise. It was anticipated that participants would experience more difficulty memorising the faces from the virtual photographic gallery when visual noise was present rather than absent.

In addition to creating a dynamic and compelling experimental environment for participants to engage in a memory task, consider two other ways in which the present methodology develops the procedures used previously. First, in all the earlier studies, participants retrospectively estimated the duration of a task that they performed in a static mode. In the present experiment however, when participants become immersed within the virtual photographic gallery, the continuous stream of visual input that is projected on the retina by the HMD (i.e., optic flow) creates the illusion of movement for participants during the critical task interval (note that participants will not receive vestibular or propioceptic feedback cues as they will be seated in the physical room). In everyday life, people frequently estimate the duration of events that they experienced whilst stationary or moving. In this way, the use of IVET allows the generality of the reported effects to be examined across different types of situations in which time is computed on a daily basis. Second, in Experiments 1-3, ease of encoding effects on judgments of remembered duration were obtained in task contexts in which participants were required to visually encode written words during the critical interval. It is important however to consider different types of stimulus events that people experience in the real world. By using pictorial visual stimuli in the present experiment, it becomes possible to determine whether these effects generalise to other ecological stimulus events.

Other modifications to the previous methodology involve the duration of the task interval to-be-estimated and the horizontal interval scale used for participants' retrospective duration estimates. In the current study, the memory task in the immersive virtual photographic gallery will last for a total duration of 1 min 15 s. As this is a different objective clock time duration from any used previously, this will assess the extent to which the reported effects generalise to other temporal durations in the second and minute range. In the earlier ease of encoding laboratory-based experiments (Expts. 1-5), duration estimates were made via a circled response at a set point along the horizontal interval scale. However, in this experiment (as in the previous chapter), retrospective duration estimates will be made by making a mark along a fixed line length scale. As such, participants will be able to estimate the duration of the task to the nearest second. This alternation makes it possible to determine whether the ease of encoding effects reported thus far extend to other duration judgment scales.

As long as the visual noise manipulation is successful in eliciting different encoding experiences for participants in the two experimental conditions, the experience-based hypothesis predicts the following. If people use their prior encoding experiences to compute elapsed time, then duration estimates should decrease as the perceived difficulty of encoding operations increase. That is, when the encoding task is perceived to be difficult (i.e., visual noise present), people will report that less time was available to commit the faces to memory compared to when the encoding task is perceived to be relatively easy (i.e., visual noise absent). The content-based hypothesis predicts that if people draw on the amount of stimulus information stored in memory to compute elapsed time, then duration estimates should closely parallel memory for the amount of information remembered from the task. That is, if the encoding task leads to increased, decreased, or equivalent memory for the presented faces compared to the other task, people will report that more, less, or the same amount of time was available to commit these items to memory.

5.2.1 Method

Participants and Design

Forty undergraduate students (18 men and 22 women) from the University of California, Santa Barbara participated in the experiment in partial fulfilment of a

course requirement. All participants were Caucasian, native speakers of English and had normal or corrected-to-normal vision. None of the participants had a self-reported history of epilepsy or a medical condition that affected their spatial/visual abilities. The study had a single factor (visual noise: absent or present) between-subjects design. An equal number of men and women were randomly assigned to each of the experimental conditions.

Materials and Apparatus

The physical room (i.e., laboratory) in which the experiment took place was approximately 3 m x 2.4 m x 3 m. A non-swivel chair was positioned in the centre of the room for participants. From this position, the virtual photographic gallery was modelled as 56 m x 5 m x 5 m. As such, the length of the virtual room was over 11 times greater than the width which ensured that the illusion of a long hallway in the gallery was created. The virtual photographic gallery comprised golden brown wood panelling for the two side walls (east and west in the virtual room) and the ceiling. The north facing wall at the end of the gallery hallway was coloured black with no added texture. The floor had a green marble effect. 20 photographic portraits framed in dark wood (1.3 m x 2.8 m) were suspended from the centre of the ceiling (0.5 m) by dark wooden beams; each beam was attached to the top midpoint of each frame. The framed portraits were stationary and were positioned at 2.8 m intervals along the length of the gallery hallway.

The photographic portraits were in colour and each comprised a frontal view of a person's face with a neutral expression (i.e., eyes open, mouth closed, no smile). 90 students at the University of California, Santa Barbara consented to be photographed and signed a form granting the experimenter permission to use the image of their face for research purposes. All photographs were shot on campus using a digital camera. 20 of these photographs of people's faces (10 men and 10 women) were selected and resized (1.2 m x 2.7 m) to appear within the virtual photographic gallery. In one condition, the photographic portraits of people's faces were presented without visual noise (see Appendix 6 for the stimuli used). In the other condition, the same faces were presented in the same order with visual noise (a dot density mask of 65%; see Appendix 7). It was anticipated that visual noise (absent vs. present) would moderate the encoding experience (easy vs. difficult respectively). Figure 2 shows a snapshot of the virtual photographic gallery in each of the experimental conditions.

Figure 2.

Snapshots of the Virtual Photographic Gallery in the Two Experimental Conditions

Visual noise absent

Visual noise present

Virtual movement forwards through the length of the gallery hallway at a velocity of 0.75 m/s allowed the 20 photographic portraits of people's faces to be viewed sequentially (see Appendix 6 or 7 for the order of presentation). Each portrait was viewed frontally and was only visible for 3.75 s before it was passed under and the next one appeared. The virtual environment turned pitch black when all 20 portraits had been presented. The total duration of the virtual journey through the virtual photographic gallery was 1 m 15 s.

An additional 20 photographs of people's faces were selected to serve as distractors in the recognition test (see Appendix 8 for the stimuli used). Each distractor item was chosen to match a target item (i.e., gallery photographs) based on gender, race, hair colour, and neutral expression. In the recognition memory test, the 40 photographs of people's faces (20 targets and 20 distractors) were presented sequentially and in a random order in a PowerPoint slide presentation on a computer monitor. The photographs measured 14.07 cm x 16.12 cm and were presented in colour on a white background without visual noise or wooden portrait frames.

The technology used to render the immersive virtual photographic gallery is shown in Figure 1 (see page 130). Participants wore a Virtual Research V8 Head Mounted Display (HMD) that comprised stereoscopic LCD panels over each eye with a resolution of 1280 x 480 and a refresh rate of 72 Hz. This ensured that the virtual photographic gallery could be viewed separately by each eye to give stereoscopic depth. While immersed within the virtual gallery by wearing the HMD, participants could not see any part of their own body or anything in the physical room. The eye height of participants in the immersive virtual gallery was set at 0.7 m to control for height differences. The displayed images in the HMD were generated using a 450 MHz Pentium III dual-processor computer with an Evans & Sutherland Tornado 3000 graphics card. A tracking system was utilised to determine the position, orientation, and eye movement of the participant in the physical room. This allowed the participant's field of view in the virtual room to be continuously updated by the rendering computer so that realistic three-dimensional visual stimuli were experienced in the immersive virtual photographic gallery. For example, when the participant looked up to view the portrait of a person's face just before passing underneath it, that particular viewpoint would be made visible on the stereoscopic

displays of the headset. The time delay, or lag between tracking and rendering was almost negligible (40 ms).

Procedure

Participants arrived at the laboratory individually and were asked to sit on a chair positioned in the centre of the room. Participants were informed that the study was an investigation into human memory. Attention was then drawn to the head mounted display (HMD) which was located on a stand near to where the participants were sitting. It was explained that when the HMD is worn, a person can see three-dimensional virtual environments and that people often describe this experience as "being inside a movie". Participants were told that they would be wearing the HMD as they sat on the chair for part of the experiment and whilst wearing it, they would feel as if they were inside a photographic gallery. The experimenter then gave the following instructions to participants:

> When you are inside the photographic gallery, you will be taking a virtual journey through the gallery hallway on a moving walkway. On this journey, you will see a number of photographic colour portraits of people's faces hanging from the centre of the ceiling. Your task is to carefully study and memorise these faces as later you will be given a memory test to see how many of them you remember. The portraits of people's faces will be directly in front of you, but you will only be able to see one of them at a time. When you see one of these portraits, focus on the face for as long as you can, because you will pass underneath it and the next one will appear in front of you. As such, you should look straight ahead at all times during your journey through the photographic gallery, but you will need to move your head upwards and downwards so you can inspect each face until it disappears out of sight and the next face appears in view. The virtual photographic gallery will turn pitch black when you have seen all the portraits of people's faces.

No information was given regarding the number of faces that would be presented during the virtual journey through the photographic gallery or the length of time that would be spent performing the memory task (1 min 15 s). Once these instructions were understood, participants were told that it was now time to try on the HMD

whilst they were seated. Before the experimenter helped participants to do this, they were informed that some people can experience mild dizziness or nausea (so called simulator sickness) when they view virtual environments through the HMD equipment. It was explained to participants that if they felt uncomfortable in any way, they should say so immediately and the experiment would be stopped. The experimenter then carefully adjusted the HMD and asked participants to look straight ahead. Participants were then told that the face-memory task in the virtual photographic gallery would begin when the experimenter said "start" and would end when the experimenter said "finish". By using these signals, the task interval (i.e., to-be-assessed duration) was clearly delimited for participants. During the task interval, all participants were given 1 min 15 s to memorise the 20 photographic portraits of people's faces in the virtual gallery. Half of the participants studied the faces presented without visual noise; the other participants studied the same faces presented with visual noise.

After the encoding task in the immersive virtual photographic gallery was completed, the experimenter helped participants to remove the HMD. Once the experimenter had checked that participants were not feeling dizzy or nauseous, the Remote Associates Test (Mednick & Mednick, 1967) was performed as a distractor activity. This comprised a booklet of words that were clustered in groups of threes. Participants were required to write down a word in the space provided that had a remote association to the 3 listed words. This filler task was carried out to clear short-term memory and again, participants were not informed as to how long they would be given for the task. A 5 min period was accurately timed using a concealed stopwatch and then the booklets were collected.

Next, participants were presented with a short questionnaire consisting of two questions that related to the face-memory task performed in the immersive virtual photographic gallery. The order of presentation of the questions was counterbalanced across the two experimental conditions. Participants were told to answer the questions in the order presented and to be as accurate as possible in their responses. One question required participants to estimate how much time they believed had elapsed during the memory task in the photographic gallery. The question sheet stated that the duration to-be-estimated began when the experimenter said "start" and ended when the experimenter said "finish". A duration judgment scale was provided

ranging from 45 s to 1 min 35 s with intervals of 10 s. Ticks to mark the 1 s intervals were also clearly indicated along its length. Participants were asked to use the scale to mark off their subjective impressions of elapsed time to the nearest second. The other question required participants to rate how much difficulty they had experienced memorising the faces from the photographic gallery. Ratings were made on a 9-point scale ranging from 1 ('*very easy*') to 9 ('*very difficult*').

Finally, a visual recognition memory test was administered to assess participants' recollections of the faces from the immersive virtual photographic gallery. This involved participants viewing 40 photographs of people's faces (20 targets & 20 distractors) in a PowerPoint slide presentation on a computer monitor. The order of presentation of the faces was randomised. Participants were instructed to tell the experimenter whether each face had been seen earlier in the photographic gallery (say "OLD") or had not been seen earlier in the gallery (say "NEW"). The recognition test was performed at a participant-paced rate and the experimenter noted down the participants' responses on the relevant questionnaire. On completion of the task, participants were asked if they had recognised any of the faces because they knew the individuals personally. None of the participants indicated so. Participants were then debriefed as to the real purpose of the experiment, thanked for their assistance, and dismissed. None of the participants reported or appeared to suffer from simulator sickness during the experiment and none had guessed that their time estimation abilities were under investigation. All participants believed that human memory was the main area of interest and thus duration judgments were formed in retrospect as required.

5.2.2 Results and Discussion

Perceived Task Difficulty

To assess whether the memory task was accompanied by different encoding experiences, participants' difficulty ratings were submitted to a single factor (visual noise: absent or present) between-subjects ANOVA. This analysis confirmed that visual noise had the intended effect on perceived task difficulty, $F(1,38) = 13.90$, $p < .0006$. Participants found it easier to memorise the faces from the virtual photographic gallery when visual noise was absent rather than present (see Table 9 for treatment means).

Duration Estimates

Participants' retrospective duration estimates were converted to seconds and the resultant data were submitted to a single factor (visual noise: absent or present) between-subjects ANOVA. As expected, this revealed an effect of visual noise on participants' duration judgments, such that more time was believed to have been available to memorise the faces from the virtual photographic gallery when noise was absent rather than present, $F(1,38) = 26.70$, $p < .0001$ (see Table 9 for treatment means). As participants' estimates of elapsed time varied as a function of their experienced ease or difficulty of encoding, this provides further support for the experience-based hypothesis of retrospective duration estimation.

Recognition Accuracy

For each participant the number of correctly recognised faces was corrected for guessing by subtracting the false-alarm rate from the hit rate. The corrected number was then converted into a proportional score which served as a measure of recognition accuracy. The resultant scores were submitted to a single factor (visual noise: absent or present) between-subjects ANOVA. This analysis revealed no effect of visual noise on recognition accuracy, $F(1,38) < 1$, *ns* (see Table 9 for treatment means). Participants correctly recognised the same number of faces from the virtual photographic gallery regardless of whether visual noise had been absent or present. This suggests that participants must have expended greater effort memorising the faces that were degraded with noise (see difficulty ratings below).

Table 9.

Mean Ratings of Duration (s), Task Difficulty, and Recognition Accuracy as a Function of Visual Noise (standard deviations in parentheses)

Visual Noise	Duration Estimates	Task Difficulty	Recognition
Absent	72.65 (8.55)	3.60 (1.60)	.385 (.15)
Present	60.35 (6.34)	5.30 (1.26)	.350 (.12)

The observed pattern of time estimation results again presents problems for a content-based hypothesis of retrospective timing (Ornstein, 1969). The two face-memory tasks performed in the immersive virtual photographic gallery produced equivalent recognition accuracy, but they were not judged as equal in remembered duration. Thus, as retrospective duration judgments were not directly related to the number of items remembered from the judged interval, participants could not have used the amount of information stored in memory as a cue to compute elapsed time. As the only physical difference between the two memory tasks was the absence or presence of visual noise, the experience-based hypothesis provides the best explanation of the current findings. Visual noise (absence vs. presence) was sufficient to elicit different encoding experiences (easy vs. difficult respectively) and participants seemed to use this experience of ease or difficulty as input for their subsequent duration judgment. When the encoding task was considered to be subjectively difficult or demanding (i.e., visual noise present), participants believed that less time had been available to commit the gallery faces to memory compared to when the encoding task was considered to be relatively easy (i.e., visual noise absent).

Duration Estimates and Difficulty Ratings

Further evidence for this conclusion was obtained by a correlational analysis. Participants' duration estimates decreased as their reported difficulty of encoding the faces increased, $r(38) = -.628$, $p < .001$. As the results fulfilled the conditions required for testing mediation (Baron & Kenny, 1986), an ANCOVA was performed to assess whether the subjective difficulty of encoding operations mediated the effect of visual noise on participants' duration estimates. This analysis revealed that when task difficulty ratings were partialled out of the analysis, the effect of visual noise on duration estimates was reduced, but not eliminated, $F(1,37) = 10.88$, $p < .002$. Thus, as in the previous encoding studies (Expts. 1-5), the experienced ease or difficulty evoked by encoding operations exerted a mediational influence on participants' retrospective duration judgments. This effect however was not as pronounced as in Experiments 1-3, when performance was indexed by free recall rather than recognition accuracy.

The current results therefore replicate and extend those observed in Experiments 1-5. As before, participants' judgments of remembered duration were influenced by the

subjective ease or difficulty of a prior encoding episode. More time was reported to be available to memorise the faces from the virtual photographic gallery when the task of placing this information into mind was considered to be a relatively effortless activity (i.e., visual noise absent). Conversely, less time was reported to be available to memorise the gallery faces when the task of placing this information into mind was experienced as effortful and demanding (i.e., visual noise present). Thus, these findings are again consistent with the hypothesis that people use their prior encoding experiences as a cue to estimate how much time has elapsed during a task. As these ease of encoding effects were obtained in the absence of memory recognition differences, this conclusion is further supported.

The results of the correlational and mediational analyses also confirm this experience-based account of retrospective timing. The correlational analysis revealed that judgments of elapsed time decreased as encoding operations were perceived to increase in difficulty and the mediational analysis verified the influential role played by the experienced ease or difficulty of encoding in retrospective duration estimation. However, as in the mediational analyses conducted for Experiments 4 and 5, the effect of the independent variable (i.e., visual noise) on duration estimates was attenuated rather than eliminated when task difficulty ratings were partialled out of the analysis. Presumably as before, this failure to completely eliminate the effect of visual noise on participants' duration estimates is undoubtedly due to the magnitude of the original effect.

Taken together, the results of the present experiment show that people pay attention to their experiences of ease or difficulty associated with memory encoding and use the information they provide to guide their retrospective duration judgments. The current findings also extend the previous encoding studies in a number of important ways. Critically, these experiential influences on judgments of remembered duration were obtained in an immersive virtual photographic gallery rather than in the traditional laboratory environment. This clearly demonstrates the generality of experiential effects across different experimental settings (i.e., laboratory and virtual environments). Moreover, in contrast to the earlier laboratory-based experiments, duration judgments were returned for an easy or difficult encoding task that had been performed whilst moving (albeit, "virtually"). This provides supporting evidence that ease of encoding effects emerge for situations that are experienced in a moving or in

a stationary mode. The observed findings also extend the previous work as the visually encoded items were of a different nature, the duration of the task interval was of a different length, and the horizontal interval scale used for the duration estimates was of a different type, nevertheless comparable effects emerged. Thus, ease of encoding effects generalise to different stimulus types, objective clock time durations in the second and minute range, and duration judgment scales. Evidently, experiential effects on judgments of elapsed time are remarkably robust.

5.3 CHAPTER DISCUSSION

The prime objective of Experiment 9 was to determine whether ease of encoding effects on judgments of remembered duration extend from traditional laboratory settings to more dynamic task environments. Immersive virtual environment technology (IVET) was used to create an engaging and compelling synthetic experimental environment so this issue could be investigated in a situation similar to one experienced in the real world. While the immersive virtual environment (i.e., photographic gallery) simulated the essential characteristics and richness of the natural social environment, this came at no expense to experimental control.

Under these unique experimental conditions, strong evidence was obtained that subjective experiences of ease or difficulty evoked by memory encoding operations play an important role in the construction of retrospective duration judgments. When the task of encoding the faces presented in the immersive virtual photographic gallery was experienced as easy (i.e., visual noise absent), participants interpreted this to mean that they were given a sufficient amount of time to commit these items to memory. Thus, long retrospective duration judgments were provided by these participants. In contrast, when the task of encoding the gallery faces was experienced as difficult (i.e., visual noise present), participants interpreted this to mean that they were not given enough time to commit these items to memory. This was reflected in their shorter judgments of elapsed time. This pattern of findings again shows that the subjective experience of finding it relatively easy or considerably difficult to commit items of information to memory elicits a distinctive experiential mental state that conveys useful information to the time estimator. Moreover, as these ease of encoding effects emerged in a digital immersive virtual environment rather than in the traditional laboratory environment (Expts. 1-5), the generality and importance of

the findings reported in this thesis is highlighted. Experiential effects readily extend across different experimental situations (i.e., physical and virtual). In demonstrating this, positive implications arise for IVET at a general level. Valid and valuable experimental social psychological research can be conducted using digital IVET. Undoubtedly, it is a powerful research tool for augmenting the traditional methods of studying human behaviour in more dynamic experimental settings – in the present context, people's time estimation abilities.

While the results of the virtual environment-based experiment further confirm the experience-based hypothesis, the observed findings once again fail to corroborate the content-based account of retrospective duration estimation (cf. Ornstein, 1969). The expected positive relationship between judgments of remembered duration and memory for the presented interval items was not found. There were large differences in remembered duration between the two face-memory tasks, whilst recognition accuracy for the gallery faces was equivalent. Thus, the conclusion can be made that the amount of information stored in memory played no role in shaping people's retrospective duration judgments. Unlike the studies in the previous chapter, no deliberate attempt was made in the current experiment to manipulate the amount of contextual change that was experienced during the to-be-judged interval. Despite this however, varying amounts of contextual change might have been in operation as the two face-memory tasks were performed and this in turn might have affected people's judgments of elapsed time. For this reason, the contextual-change hypothesis of retrospective timing (Block, 1989a; Block & Reed, 1978) warrants brief discussion. Can this hypothesis provide an explanation for the obtained results?

In the present experiment, the subjectively easy encoding task (i.e., faces without visual noise) performed in the immersive virtual photographic gallery was judged as longer in duration than the subjectively difficult encoding task (i.e., faces with visual noise). The contextual-change hypothesis would have to explain this pattern of findings by assuming that the easy task caused more contextual change to be encoded and stored in memory than the more difficult version of the same task. As the only physical difference between the two encoding tasks was the absence or presence of visual noise, advocates of the contextual-change hypothesis would have to argue that this manipulation was responsible for causing this memory-change difference. It seems more likely, however, that performance on the difficult task would cause more

contextual change to be stored in memory than performance on the easy task. In the difficult task, the presence of visual noise over the to-be-remembered faces would presumably cause participants to encode a greater number of different interpretations of these faces than in the easy task when visual noise was absent. Various interpretations of the presented faces should therefore lead to more changes in processing context (Block, 1990). Of course, as the contextual-change hypothesis fails to incorporate any independent way of establishing the extent of contextual change, time researchers are left with no alternative but to infer the amount of change in memory storage. If this reasonable assumption is accepted, the change-based hypothesis also encounters problems as the difficult task should have produced longer rather than shorter retrospective duration judgments. It can thus be assumed that unintentional contextual influences were in operation during the two face-memory tasks, but they failed to directly influence people's judgments of elapsed time.

In sum, although the traditional memory-based accounts (i.e., content and change) of retrospective duration estimation have been considered, the experience-based hypothesis continues to provide the best explanation of the observed findings. People use their experiences of ease or difficulty associated with prior encoding operations as a cue to guide their retrospective duration judgments. As such, the present research is compatible with related work in social cognition that highlights the role of subjective experiences in other domains of judgment (e.g., Clore, 1992; Kelley & Jacoby, 1996a; Schwarz, 1998; Schwarz & Clore, 1996; Strack, 1992).

CHAPTER 6

GENERAL DISCUSSION

How people make their assessments of elapsed time is a question that has captured the attention of many cognitive psychologists (e.g., Block, 1978; Fraisse, 1963; Frankenhaeuser, 1959; James, 1890; Ornstein, 1969). Undoubtedly, interest in this topic stems from the fact that retrospective timing plays such a pivotal role in daily life. The assumption in this domain of research is that people use the contents of memory (i.e., products of retrieval) to guide their retrospective duration judgments (e.g., Block, 1989a; Block & Reed, 1978; Ornstein, 1969); an assumption that has also dominated the general area of social judgment (e.g., Higgins, 1989; Wyer & Srull, 1989). Although this postulation has been useful for guiding a considerable amount of research on retrospective temporal estimation, a poor understanding of how people compute elapsed time still remains.

In the social judgment research, however, it is becoming increasingly clear that an analysis of decision-making based solely on the accessible contents of memory retrieval is incomplete. Alternative lines of research in social cognition have now shown that subjective experiences that accompany information processing also convey useful information that people rely on when they make judgments, evaluations, and appraisals (e.g., Clore, 1992; Jacoby & Kelley, 1987; Kelley & Jacoby, 1996a; Schwarz, 1998; Schwarz, Bless, et al., 1991; Schwarz & Clore, 1996; Strack, 1992). Thus, as it turns out, not only are the products of cognitive operations influential in shaping people's judgmental decisions, but so too are subjective experiences associated with these operations.

Given therefore the importance of subjective experiences in the derivation of social judgment, I began this thesis with the belief that it was time to investigate the usefulness of this experience-based approach in the retrospective timing domain. It was hoped that by extending the retrospective duration judgment research in this way, valuable new insights would emerge into the cognitive dynamics of retrospective duration estimation. The primary goal of the current research was therefore to determine the extent to which subjective experiences of ease or difficulty

associated with prior processing operations (i.e., memory encoding and memory retrieval) would influence people's retrospective duration judgments.

6.1 SUMMARY OF CURRENT FINDINGS

Of critical importance to the rationale of the present research was that the current studies satisfied the requirements of retrospective timing tasks. The defining characteristic of such tasks is that participants only acquire a "temporal motive" (Doob, 1971) when they are unexpectedly given the duration judgment instructions after the critical interval has elapsed. In all nine of the current experiments, participants were asked if they had suspected that the experiment was concerned with time estimation. None of the participants reported any suspicion, hence their duration judgments were formed in retrospect as required.

With regard to the primary objective, the observed results from all nine experiments show that participants' retrospective duration judgments were influenced by their experiences of ease or difficulty associated with prior processing operations. Longer duration judgments were returned when the encoding or retrieval task was experienced as subjectively easy compared to when the encoding or retrieval task was experienced as subjectively difficult. These experiential effects were found to be remarkably robust as they readily generalised across different task contexts, manipulations of processing difficulty, stimulus types, perceptual modalities, intentional/incidental memory tasks (i.e., participants knew/did not know that memory would be assessed for the encoded or generated items), and memory measures. In addition, these effects were consistent across various objective clock time durations, all within the second and minute range, typically used in retrospective timing research, and across two different duration judgment scales. Moreover, these experiential influences on judgments of remembered duration also emerged in a dynamic environment that mimicked a real world situation, specifically in an immersive virtual photographic gallery. This uniquely demonstrated the generality of these effects across different experimental settings (i.e., laboratory and virtual environments).

This consistent pattern of findings provides strong support for the assumption that people use their inferences about the subjective ease or difficulty of prior processing

operations as a cue to guide their judgments of remembered duration. When items of information were encoded into memory or retrieved from memory with relative ease, participants interpreted this experience of ease to mean that sufficient time must have been available to perform the task. Thus, long retrospective duration judgments were provided by these individuals. Conversely, when items of information were encoded into memory or retrieved from memory with considerable difficulty, participants interpreted this experience of difficulty to mean that insufficient time was available to perform the task in a satisfactory manner (e.g., performance may have felt pressurised or rushed). This caused shorter retrospective duration judgments to be reported. In this way, participants considered the ease or difficulty they experienced placing items into the mind, or bringing items to mind as a reliable and predictive indicator of how much time was available to perform the task. Simply stated, individuals seem to perceive their experienced processing ease or difficulty to be a relevant and highly informative source of information for their retrospective duration judgments and so they use it to guide their temporal outputs.

In line with this assumption, the results of the correlational analyses corroborated the relationship between participants' retrospective duration judgments and their ratings of processing difficulty. Judgments of elapsed time decreased as processing operations were perceived to increase in difficulty. Most importantly, the mediational analyses provided direct evidence for this experience-based account of retrospective timing. In all nine experiments, the subjective ease or difficulty of prior processing operations was found to either mediate (Expts. 1-3, 7-8) or to play an influential mediational role (Expts. 4-5, 6, 9) in people's judgments of remembered duration. That is, when participants' ratings of processing difficulty were partialled out of the analysis, experiential effects on their assessments of elapsed time were eliminated or attenuated respectively. With the exception of Experiment 6, in the experiments in which subjective experiences were found to exert a less pronounced mediational influence on people's temporal outputs, memory performance was indexed by recognition accuracy rather than free recall. Interestingly, there seems to be a fundamental difference between these two memory measures. Future research is clearly needed to identify the source of this difference.

A clear take-home message therefore emerges from the current research. Subjective experiences of ease or difficulty associated with both memory encoding (Expts. 1-5,

9) and memory retrieval (Expts. 6-8) play an important role in retrospective duration estimation. Put another way, people use their experiential cognitive state as a cue to guide their retrospective duration judgments: at least for temporal durations in the second and minute range and in task contexts similar to those used here. Before the theoretical and practical implications of these findings are discussed, a summary of the results would not be complete without considering the impact of experiential effects on judgmental accuracy. In fact, one of the main reasons for investigating the processes mediating retrospective duration judgments is that there is an objective standard (i.e., clock time) against which their level of accuracy can be assessed.

When the encoding or retrieval task was deemed to be subjectively easy, participants showed remarkable precision in estimating how much time had elapsed. In general, they only slightly underestimated the task's objective clock time duration. However, when the encoding or retrieval task was deemed to be subjectively difficult, participants' estimates of elapsed time were somewhat shorter. That is, they underestimated objective time to a much larger degree. These findings show that reliance on an experience-based judgmental strategy under easy processing conditions produces fairly accurate retrospective duration estimates. In contrast, under difficult processing conditions, reliance on such a strategy actually causes inaccurate duration estimates to be produced; an issue that will be considered in more detail later. Some general similarities in participants' retrospective duration judgments will also be pointed out as a matter of interest.

Remembered duration was affected by the actual length of the task interval as judgments became more inaccurate as the interval lasted for a longer duration. That is, retrospective timing performance was better when shorter rather than longer durations were estimated (e.g., 1 min 30 s vs. 3 min 18 s). However, regardless of the actual length of the time period under investigation, retrospective duration judgments were almost always underestimates of clock time, with underestimates becoming more pronounced as objective duration increased. Both are typical findings in this area of research (e.g., Block & Zakay, 1997; Brown & Stubbs, 1988; Predebon, 2002). In general then, it seems that when assessments of elapsed time are made for intervals in the second and minute range, there is a strong tendency to underestimate the interval's objective duration and greater inaccuracy characterises longer time periods.

6.2 THEORETICAL IMPLICATIONS

6.2.1 Implications for Research on Retrospective Timing

By demonstrating the influential role played by subjective experiences in the construction of retrospective duration judgments, important theoretical implications arise for retrospective duration estimation research. The present work suggests that the traditional memory-based duration judgment models that focus exclusively on the contents of memory (i.e., products of retrieval) can not predict people's judgments of remembered duration in all tasks contexts or situations. Throughout the current research, the predictive utility of the two dominant memory-based models in the retrospective timing literature were tested and the message that emerged was straightforward. The observed pattern of time estimation results could not be adequately explained by either of these traditional duration judgments models.

According to Ornstein's (1969) long-established storage-size model, people base their retrospective duration judgments solely on the amount of stimulus information stored in memory during the critical task interval. This hypothesis therefore predicts that a positive relationship between these two variables should always emerge. That is, duration judgments should closely parallel memory for the amount of information remembered from the time period. In the present experiments, however, despite using memory measures of both free recall and recognition, evidence of this positive relationship was rather limited. In fact, in seven of the nine experiments, judgments of remembered duration were found to be unrelated (Expts. 1-3, 5, 9) or inversely related (Expts. 7-8) to the amount of information recalled or recognised from the critical interval. Obviously, such findings cast doubt on a purely content-based account of retrospective duration estimation.

In stark contrast to the aforementioned hypothesis, the predictive utility of the other dominant explanation of how people form an impression of elapsed time was only tested in two of the experiments in this thesis. Block's (1989a; Block & Reed, 1978) contextual-change model postulates that people base their retrospective duration judgments solely on the amount of contextual change that is experienced and stored in memory during the critical interval. As such, this hypothesis predicts a positive relationship between judgments of remembered duration and the number of

contextual changes that are remembered from the time period. As already explained, difficulty in testing this change-based account of retrospective timing stems from the fact that this model fails to incorporate any independent way of establishing the extent of contextual change in a given situation. Time researchers are therefore left with no alternative but to infer the amount of contextual information in memory storage. This ambiguity is further exasperated as no precise specification of contextual change is offered. Until there is an agreed-upon-measure of contextual change, this hypothesis of retrospective timing can not be tested directly.

Despite these problems, a manipulation of contextual change was attempted in the present research (Expts. 7-8). The reasonable assumption was made that the number of items self-generated during the critical interval (i.e., many vs. few) provides an index of the amount of contextual change that is experienced and stored in memory (i.e., more vs. less respectively). The results obtained were the exact opposite to what the contextual-change hypothesis would predict. That is, retrospective duration judgments were found to be inversely rather than directly related to the number of contextual changes that occurred during the judged interval. These findings therefore call into question the idea that contextual change serves as the sole determinant of remembered duration.

What is abundantly clear from the lack of supporting evidence for either of the traditional memory-based models of retrospective timing is that that these models provide an incomplete view of how people estimate elapsed time. That is, they fail to fully capture the complexity involved when people make retrospective duration judgments. Whilst the contents of memory (i.e., the amount of stimulus information or contextual information remembered) can presumably serve as an informative judgmental cue in some time estimation situations, the current work strongly suggests that this is not the only cue that people use. The consistent pattern of results obtained throughout this thesis provides compelling evidence that people use subjective cues to guide their judgments of elapsed time, cues that relate to their experiences of ease or difficulty associated with memory processing operations.

The theoretical implications of these findings are straightforward. In order to gain a more complete understanding of how memory-based operations drive people's retrospective duration judgments, time researchers need to broaden the scope of their

investigations. Rather than simply paying attention to the products of the retrieval process (i.e., what information is brought to mind), experiences of recollective ease or difficulty that derive from the actual process of encoding and/or retrieval also need to be considered (i.e., how information is placed into the mind or brought to mind). In social cognition research, the causal significance of subjective experiences in the construction of social judgment is now acknowledged (e.g., Schwarz, 1998) and the present research strongly suggests that it is time for retrospective temporal estimation research to do the same.

In summary, retrospective duration judgment formation is far more complicated than originally presumed. In contrast to what the traditional memory-based models suggest, the current work shows that people do not always rely on the quantity of information they can remember as a cue to guide their judgments of elapsed time. Rather it seems that in task contexts similar to those used in the current studies, people derive informational input for their temporal judgments from the experiential quality of mental operations (i.e., encoding, retrieval) that furnish their minds with these inputs. That is, retrospective duration judgments are made by assessing the ease or difficulty with which a relevant mental operation can be carried out. It seems that an understanding of the underlying processes mediating judgments of remembered duration will only come from acknowledging the importance of both of these sources of information.

6.2.2 Implications for Research on Subjective Experiences

The current research also has a number of important theoretical implications for previous experience-based research in social cognition. In this domain, a large number of studies have investigated the effects of subjective experiences of ease or difficulty evoked by memory retrieval operations on everyday social judgments (e.g., Rothman & Hardin, 1997; Schwarz, 1998; Schwarz, Bless, et al., 1991). Whilst this body of work provides compelling evidence that subjective retrieval experiences can function as a highly informative judgmental cue, the judgments under investigation have pertained, in large part, to subjective domains. Namely, self-related judgments that have no objectively correct answer. For example, ease of retrieval has been found to influence judgments of self-perception (e.g., Schwarz, Bless, et al., 1991), judgments of health risk (e.g., Rothman & Schwarz, 1998), judgments of childhood

memory (e.g., Winkielman et al., 1998), judgments of attitude strength (e.g., Haddock et al., 1999), and other attitude-related judgments (e.g., Wänke et al., 1996). By demonstrating that the same experiential influences emerge for a judgment more objective in nature, specifically people's judgments of remembered duration, the present research confirms that ease of retrieval effects are not restricted to self-related judgment. Rather, it seems that one and the same kind of subjective experience can influence judgments of very different natures, that is, judgments in both subjective and objective domains.

In addition to uniquely showing that experiences of ease or difficulty associated with retrieval operations can serve as a useful source of information for judgments of elapsed time, the current research also shows that even when these experiences are elicited by encoding operations they still function as an informative judgmental temporal cue. Ease of retrieval effects therefore readily extend to the first stage in the memory process, namely encoding. As such, it becomes clear that it is not the memory processing operation that acts as input to the retrospective duration judgment, but rather the experience of ease or difficulty that was associated with the cognitive process. This is an important extension of previous research in this domain as investigations have focused exclusively on determining the extent to which experiential aspects of memory retrieval hold informational value for the judgmental process (e.g., Schwarz, 1998). In this body of work, participants are required to retrieve a specified number of items of information that already reside in long-term memory (e.g., few vs. many self-assertive behaviours; Schwarz, Bless, et al., 1991). The nature of the task can thus cause participants to have different retrieval experiences (i.e., easy vs. difficult respectively), but encoding experiences are completely absent.

By continually using this experimental paradigm, no interest has been paid to whether people's judgmental outcomes can also be affected by experiential aspects of memory encoding (i.e., by assessing how easy or difficult it was to commit items of information to memory). The present research however demonstrates the utility of considering subjective experiences of ease or difficulty associated with both memory encoding and memory retrieval operations in an attempt to understand people's retrospective duration judgments. Thus, from a theoretical viewpoint, it appears that social cognition research would also benefit from paying attention to the experiential

concomitants of both of these memory processing operations. After all, it is likely that the subjective ease or difficulty of encoding operations will inform a variety of judgments in the same way already observed for subjective experiences accompanying retrieval operations.

At a more general level, the present work also converges on the conclusion that subjective experiences accompanying information processing play a larger and more direct role in human judgment and decision-making than originally presumed (e.g., Clore, 1992; Jacoby & Kelley, 1987; Kelley & Jacoby, 1996a; Schwarz, 1998; Schwarz & Clore, 1996; Strack, 1992). It has been shown that subjective experiential states of different types, specifically, affective, bodily, and cognitive feelings, all serve as useful and valid information that people rely on when they make a wide range of everyday judgments. When one considers that such feelings (e.g., "I'm hot", "I'm hungry", or "That task was really difficult") are commonly evoked, immediately accessible, and therefore easily read, it is not that surprising to learn that we pay attention to the informational cues they convey to us (Strack, 1992). What is more, not only are our feelings important and meaningful to us, but we generally believe them wholeheartedly, so it makes sense that we make use of the information they provide to guide our judgmental outputs (Clore, 1992).

With the rise of research in this experiential domain and the strong evidence that accompanies it, the early view of decision-makers as rational and logical information processors has changed (Schwarz & Clore, 1996; Tversky & Kahneman, 1973). Rather than only using systematic content-based processing strategies before reporting a judgment, as the initial work suggested, it is now clear that decision-makers can opt to rely on heuristic strategies based on their subjective experiences. The benefits of such a strategy are obvious. Instead of basing judgments on the result of an exhaustive search of memory which takes time and effort, people can use their subjective experiences to furnish a wide range of everyday judgments in a rapid and efficient manner. Basically, reliance on an experience-based judgmental strategy serves a simplifying cognitive function. It must be noted however that although people have direct awareness of their subjective experiences or feelings, this does not imply that they are consciously aware of using the information they derive from them when they make a judgmental decision (Schwarz & Clore, 1996; Strack, 1992). In a sense, using subjective experiences as a heuristic cue to arrive at a particular

judgment can be compared with how first-rate chess players or carpenters use their skills. These people would find it extremely difficult to explain the rules governing their decisions, but the end result is generally as required (Sherman & Corty, 1984).

In summary, people are far more sophisticated than previously realised when it comes to the judgmental strategies they employ in decision-making situations. People do not only use systematic strategies based on the products of cognitive operations, but they also adopt heuristic strategies or shortcuts based on their subjective experiences associated with cognitive operations. Social cognition research in a number of different areas corroborates this latter view by demonstrating that subjective experiences play a central role in various spheres of human judgment and the present research reveals that the domain of retrospective duration judgment is no exception. Clearly, to move forward in our understanding of the cognitive dynamics of human judgment, the study of subjective experiences must long continue.

6.3 PRACTICAL IMPLICATIONS

Next consider the practical implications of the current research. The practice of using the subjective ease or difficulty of prior processing operations as a cue to judge elapsed time provides a way for social perceivers to function adaptively and efficiently. This heuristic-based strategy guarantees that these judgments are formed quickly and easily which undeniably serves a useful function in our busy and complex world. Despite these benefits however, this is a downside, one with important practical implications. When the experienced ease or difficulty of information processing is used as a basis for judgment, people can easily be led astray in the inferences they make. The reason why this judgmental process can be misleading is that the experience of ease or difficulty that serves as input to the judgment is prone to misattribution (Clore & Parrott, 1991). That is, people very often fail to recognise the true source of their cognitive experience and instead attribute it to the judgment under investigation. When this is not understood and all relevant information is not considered, people's judgments can be unconsciously influenced and they can be biased or inaccurate as a direct result.

In the present research, participants misattributed their experiences of ease or difficulty evoked by processing operations as cognitive reactions to the object of judgment (i.e., the duration of the task) rather than correctly attributing them to the nature of the information processing task (i.e., task conditions). This resulted in shorter retrospective duration judgments being provided in the presence of difficult rather than easy processing experiences. Undoubtedly, in the present context, (mis)attributing the difficulty experienced to a shorter task interval rather than to the nature of the set task serves a moral-boosting function as it gives participants no reason to question their own abilities. After all, this way, participants can believe that they only experienced difficulty on the task because they were not given enough time to perform it in a satisfactory manner. While this attribution process might be successful in maintaining self-belief in their own cognitive abilities, it actually caused participants to make inaccurate assessments of elapsed time.

When participants found the encoding or retrieval task to be considerably difficult or demanding, this experience of difficulty prompted them to significantly underestimate the objective clock time duration of the task. For these participants, time seemed to pass with unusual rapidity which caused them to misremember the task's duration as shorter than it actually was. Thus, simply increasing the difficulty of the information processing task was sufficient to erroneously decrease people's perceptions of elapsed time. Conversely, when participants found the encoding or retrieval task to be relatively easy, this experience of ease caused the task interval to appear subjectively longer in duration. It is important to point out that the same judgmental inaccuracies were not evident under these subjectively easy task conditions. In fact, participants who relied on their experienced processing ease as a cue to judge elapsed time showed remarkable precision in their retrospective duration estimates. Generally, participants only slightly underestimated the task's objective duration. Clearly, under such conditions, reliance on this heuristic strategy is particularly useful as fairly accurate duration judgments are produced.

Thus, people's judgments of temporal duration in retrospect are malleable to the context in which they are formed. When easy or difficult processing experiences were elicited and used as input for the judgment, people's subjective impressions of elapsed time were altered. This finding it congruent with other experienced-based research which has highlighted the misleading effects of ease or difficulty in a wide

range of social judgments (e.g., *self-perception*, Schwarz, Bless, et al., 1991; *risk perception*, Rothman & Schwarz, 1998; *attitudes*, Haddock et al., 1999; Wänke, et al., 1996; *people*, Dijksterhuis et al., 1999; Rothman & Hardin, 1997) and non-social judgments (e.g., *frequency and probability estimates*, Tversky & Kahneman, 1973; Wänke et al., 1995; *noise*, Jacoby et al., 1988). The prevalence of such systematic judgmental biases shows that people who use their experiences of ease or difficulty accompanying information processing as a judgmental cue fail to appreciate how their judgments and evaluations can substantially change and falter as conditions vary. The same is true for other subjective experiences, such as moods (e.g., Schwarz & Clore, 1983) and arousal states (e.g., Zillman, 1978) when they are used for evaluative and physical judgments respectively. In combination, this research strongly suggests that the use of experiential information as a heuristic cue for judgment and the typical errors associated with its usage are an inevitable part of the cognitive dynamics of human judgment and decision-making.

With regards to the present research, it is worrying to find that people's judgments of remembered duration can be so inaccurate and biased when they take on board the information provided by their subjective processing experiences. After all, people's ability to estimate time accurately is essential for everyday functioning (Boltz, 1998; Michon, 1985). The results of the present research suggest however that people will only misjudge the temporal extent of a prior processing episode, to a large degree, when they experience difficulty processing the available information. Undeniably, many of our daily activities are demanding and challenging, hence difficult processing experiences are commonly elicited. This gives rise to an important question. Are there any ramifications for everyday behaviour when a person uses his or her experienced processing difficulty as a cue to compute elapsed time in daily life? It would seem so. Consider for example, a situation in which a person witnesses a crime (e.g., two armed robbers entering a bank) and is later asked by the police how long the event lasted. A number of factors in this situation could compromise that person's processing experience of the event (e.g., gun fire, screaming). Thus, it follows that if the difficulty of the processing episode influences his or her computation of the retrospective duration estimate, then that person is likely to dramatically underestimate the duration of the past event. In this instance, inaccurately estimating the event's duration could directly affect how the police would act and pursue their investigations into this crime. Thus, it becomes clear that

using one's subjective experiences to make such judgments can influence people's behavioural outcomes, in this case, those of another person. However, by understanding that judgments of remembered duration are biased in predictable ways when experiential information is used to furnish these outputs, it at least becomes possible to predict whether people will dramatically underestimate the temporal duration of some event in their recent past.

At a more general level, systematic time distortions like the one observed here as so common that metaphors about time flying by or inching along have crept into everyday language. Take for example the well known adage "time flies by when you're having fun". This implies that differences in judged duration will arise depending on whether the events filling the time period are interesting or boring. Whilst interesting and absorbing tasks often cause an apparent shortening (or speeding up) of objective time, boring tasks have the exact opposite effect; an apparent lengthening (or slowing down) of objective time. These common subjective impressions have been confirmed in various laboratory studies (e.g., DeWolfe & Duncan, 1959; Hawkins & Tedford, 1976). Expectation and anticipation are other experiences like boredom that can cause time to appear lengthened, just as the adage "a watched pot never boils" implies. Again many timing studies have verified impressions of this kind (e.g., Block et al., 1980; Cahoon & Edmonds, 1980; Edmonds, Cahoon, & Bridges, 1981). Taken together this research shows that although people have rather distinct impressions of temporal duration, these impressions are vulnerable to distortion. Many cognitive factors including perceived processing difficulty in the present context are responsible for these time distortions. Clearly then, although time is fixed, the duration judgments that people make rest heavily on the conditions of the type of information processing task they are performing. Simply stated, time is relative to what a person is doing.

6.4 SUBJECTIVE EXPERIENCE AND DURATION JUDGMENTS

6.4.1 Why is this the Preferred Route to Judgment?

In addition to developing our understanding of retrospective timing, the present research also raises some important issues that need to be addressed. In all the experiments reported in this thesis, the encoding and retrieval tasks in which

participants engaged rendered two, or perhaps three, distinct sources of information available for use in constructing their judgments of elapsed time - the subjectively experienced ease or difficulty of processing operations, the amount of stimulus information stored in memory, and perhaps, the amount of contextual change stored in memory. Despite the fact that each type of data offers relevant information for the judgment at hand, the clear pattern emerged that participants relied on their cognitive experiences of ease or difficulty evoked by memory processing rather than on the cognitive contents that came to mind when they formed their retrospective duration judgments. Thus, one issue to consider is why these individuals preferred to use an experience-based strategy to furnish their judgments? Three possible explanations will be offered. The first two relate to conclusions that have arisen from previous experience-based research and the final explanation focuses on methodological differences between the present studies and previous retrospective duration judgment research.

First, in the social judgment literature, a number of studies have demonstrated that personal relevance and involvement with the object of judgment can play an important role in determining which judgmental strategy people choose to utilise (e.g., Dijksterhuis et al., 1999; Haddock et al., 1999; Rothman & Schwarz, 1998). A finding that is compatible with the dual-process models of judgment as these variables can directly affect the level of processing motivation that people bring to a judgment task (e.g., Chaiken et al., 1989; Petty & Cacioppo, 1986). According to this body of research, when the judgment task is perceived as personally relevant and involving, individuals tend to rely on a content-based strategy reflecting on what information comes to mind as they are sufficiently motivated to engage in this kind of effortful and systematic processing. In contrast, when the task at hand is perceived as less self-relevant and involving, individuals seem to prefer to use an experience-based strategy drawing on how easy or difficult it was to bring information to mind as they are unmotivated to spend considerable time and effort attending to, scrutinising, and integrating all the available and relevant information. Processing information in this heuristic manner guarantees that unmotivated individuals can arrive at a judgmental decision quickly and with minimal effort.

From the perspective of the current research, it is difficult to think of reasons why participants would have perceived the duration judgment task as either personally

relevant or involving. After all, they were required to retrospectively estimate the length of some experimentally-defined target interval filled with information that was unimportant to them (e.g., high-frequency words, words beginning with *s*). As a result, time estimators may not have been sufficiently motivated to process judgment-relevant information systematically. Instead, they were content to rely on a heuristic processing strategy drawing on their subjective experiences of ease or difficulty evoked by memory processing operations. In line with this reasoning, it could be suggested that individuals' preference to base their retrospective duration judgments on their elicited experiences over the accessible information stored in memory may at least in part be explained by the low personal relevance and low involving nature of the judgment task. In fact, in everyday life, people are often far too busy to become highly involved in many of the judgments they make which is indicative that such heuristic-based strategies may be more the rule than the exception. That is not to say, however, that the level of personal relevance and involvement with a retrospective temporal judgment task is always low. Situational factors (e.g., offering incentives, processing information of a more important nature) and individual differences (e.g., a time expert) can presumably increase the importance of such a task which would mean that the goal of accurately forming an impression of elapsed time would be taken more seriously. Under such conditions, people are likely to forego a heuristic judgmental strategy based on their subjective experiences and instead use a more effortful systematic strategy drawing on the numerical amount of relevant and accessible information stored in memory. One task for future research will be to investigate this possibility.

A second explanation for the observed preferential use of experiential information in judgments of remembered duration bears on research showing that people have chronic tendencies to rely on certain types of information for particular judgments (e.g., Bargh, 1997; Bargh & Gollwitzer, 1994; Higgins, 1990, 1996; Smith, 1990, 1994). Relevant to the present discussion, Rothman and Hardin (1997) have recently proposed that individuals may develop habits of relying on feeling- and content-based information for judgment as a result of using that particular type of information in the past. For example, repeatedly using the subjective ease or difficulty of retrieval as input for a particular kind of judgment may signify that this type of information is more applicable to that judgment than equally accessible content-based information. In this way, learned patterns of information use in a

particular domain of judgment may actually bias people to rely upon that information again when the same type of judgment is called for.

Take for example a domain of judgment studied by Rothman and Hardin (1997, Expt. 3). Participants were asked to evaluate either a close friend or a causal acquaintance after they had recalled judgment-relevant information from memory. It was predicted that people would base their judgments of close friends on feeling-based information, in this instance, the subjective experience of ease or difficulty of retrieval, even though the highly involving nature of the task should motivate them to process the judgment-relevant information systematically. The rationale was that in everyday life, it is often the case that judgments of our close friends are based on how we feel about them so this type of information should be considered highly applicable. In contrast, it was hypothesised that this feeling-based information would seem less applicable when evaluating a causal acquaintance for the simple reason that it is not as commonly used for such judgments. The prediction was therefore made that people would consider content-based information to be more applicable for their judgments of causal acquaintances and so they would use it even though the less involving nature of the task should cause them to process the judgment-relevant information heuristically. Consistent with Rothman and Hardin's (1997) applicability-based hypothesis, judgments of close friends were based on the subjective ease or difficulty of retrieving judgment-relevant information from memory, whereas judgments of causal acquaintances were based on the number of judgment-relevant units of information retrieved. Thus, it seems that habitually relying on feeling- and content-based information for particular judgments increases the applicability of that information when the same kind of judgment has to be formed.

In much the same way, it could be suggested that people's preferential use of their feelings of ease or difficulty elicited by information processing to estimate elapsed time results from an habitual tendency to use this type of information for such judgments. It could be argued that life long experience has taught us that this feeling-based information is highly applicable when time has to be estimated. Consider for example a situation in which a task has to be performed that demands information processing. As soon as a person is faced with such a task, he or she makes an estimate of its difficulty. That is, the person decides if the task will be relatively

straightforward or mentally demanding and effortful. This estimate of task difficulty then automatically elicits an assessment of how much time is needed for its completion. Indeed an assessment that is highly functional in today's busy world. As such, there is clearly a relationship between experiences of ease or difficulty and judgments of time. In fact, in all the reported experiments, participants' estimates of task difficulty and their assessments of elapsed time were inversely related. When processing operations were taxing, participants felt that there was insufficient time to complete the task in a satisfactory manner. Thus, it could be the case that people pragmatically learn to use the mental effort they have experienced in activities they perform to infer the amount of time that has elapsed. In the present research, such learned patterns of information use may have caused perceivers to favour this readily accessible experiential information over equally accessible content-based information when their retrospective duration judgments were constructed. Simply stated, past experience may have defined experienced ease or difficulty as more applicable to this kind of judgment.

A third and final possible explanation for individuals' preference to base their judgments of elapsed time on their prior processing experiences rather than on the amount of information stored in memory concerns the way in which time was measured in the present studies. To adhere to the previous experience-based judgment research (e.g., Schwarz, Bless, et al., 1991; Rothman & Schwarz, 1998), a horizontal interval scale was chosen. Participants were required to make their retrospective duration judgment either via a circled response at a set point along the scale (Expts. 1-5) or by making a mark along its length (Expts. 6-9). Whilst the former scale closely parallels the measurement judgment method utilised by Schwarz and his colleagues, the latter scale is a slight modification of this to allow a temporal response to the nearest second. It is feasible that reliance on an experience-based strategy for judgment may be tied to this particular type of time measurement method and possibly, variants of it.

This assumption is based on the fact that both the memory-based models of Ornstein (1969) and Block (1978, 1989a; Block & Reed, 1978) which emphasise the role of the contents of memory (i.e., stimulus and contextual information respectively) in judgments of remembered duration have been tested using a different time measurement method, namely, the method of comparison. In such studies, two

temporal intervals are presented in succession and the set task is to judge the duration of the target interval by comparing it with a standard interval that either precedes or follows it. This is normally done by providing participants with a time estimation response sheet that contains two parallel horizontal lines (note that the lines are not labelled with conventional temporal units, i.e., seconds and minutes). The line at the top of the sheet represents the length of the standard interval (e.g., 50 mm) and participants are required to divide the bottom longer line (e.g., 100 mm) into two segments so that the left segment represents the estimated duration of the target interval relative to the standard interval. For example, if the target interval is perceived as longer than the standard interval, then the left segment of the bottom line would extend beyond the end of the standard line. As this comparative method requires two intervals of time to be judged relative to one another, relative duration judgments are produced (Clausen, 1950; Zakay, 1990).

When a retrospective duration judgment is made under these conditions, there is little doubt that a highly salient and informative temporal cue comes from directly comparing the contents of memory for each of the presented intervals. If more stimulus information (Ornstein, 1969) or contextual information (Block, 1989a) is remembered from one interval than the other, then that interval's duration will be judged as relatively longer in retrospect. Despite continually using this comparative measurement method, the contents of memory has been emphasised as the principal determinant of retrospective duration estimation. Of potential relevance, however, is whilst there is strong evidence that the amount of information in memory serves as a cue to infer how much time has elapsed in a relative duration judgment situation, other retrospective timing studies have shown that this type of information appears to be less important when other time estimation methods are employed (e.g., Brown, 1985; Brown & Stubbs, 1992; Kikkawa, 1983). Although not as commonly used, these methods include verbal estimation (i.e., the duration of the target interval is estimated verbally in conventional temporal units) and reproduction (i.e., the duration of the target interval has to be reproduced by pressing a button for an equivalent period of time). What is fundamentally different about these two methods from the relative approach is that absolute duration judgments are produced as only one interval is presented and judged (Clausen, 1950; Zakay, 1990); a methodology also common to the present studies.

Interestingly, this has led some researchers to assume that different cognitive processes may be involved in relative and absolute retrospective duration judgments (e.g., Predebon, 1988; Zakay, 1993). In relative time estimation situations, it is strongly believed that the process of estimating duration in retrospect involves an assessment of the number of stimulus events or contextual changes that are remembered. However, no conclusions have been made as to the nature of the time estimation process that mediates absolute remembered duration. This is primarily due to the fact that the comparative judgment method has dominated this research area and thus the memory-based models were developed to explain how people form relative retrospective duration judgments. At the present time, these researchers simply assume that when time is estimated in an absolute manner, the contents of memory do not play such a prominent role in determining people's retrospective temporal outputs. After all, in this situation the duration of an interval is estimated in isolation. There is no reference to another external interval, so how can quantity comparisons be made?

The current research not only corroborates this view, but provides a potential answer to how absolute retrospective duration judgments are constructed. Specifically, when the duration of only one interval is judged in task contexts similar to those used here, people may use their inferences about the subjective ease or difficulty of prior processing operations as a judgment-relevant cue. Obviously, as only one kind of absolute time estimation method is used in the present work (i.e., a horizontal interval scale), further research is needed to empirically test this assumption with the other two absolute methods (i.e., verbal estimation and reproduction). However, if this turns out to be true and it is also shown that these experiential effects are absent in relative duration judgment tasks, the notion would be supported that reliance on an experience-based or content-based judgmental strategy is highly dependent on the nature of the time estimation method employed (i.e., absolute and relative methods respectively).

Thus, in this section, three factors have been highlighted that appear to enhance the impact of subjective experiences on people's retrospective duration judgments. These include low personal relevance and involvement with the judgment task, past experience with this type of information in this judgment domain, and the use of an absolute duration judgment method. Given that retrospective temporal estimation

research focuses on memory content, it is imperative to determine when and under what conditions people are likely to use their prior processing experiences as a basis for judgment. This is a task for future research, although it does appear that an understanding of this issue will only come from paying close attention to attributes of both the person and the situation. An assumption that is compatible with conclusions derived from previous experience-based judgment research (e.g., Rothman & Schwarz, 1998; Schwarz, 1998).

6.4.2 Individual Differences

Another issue that warrants discussion is whether individual differences can affect the influence of subjective processing experiences in judgments of remembered duration. The critical determining factor in the causation of experiential effects is that the information processing activity elicits feelings of ease or difficulty in the performer. In the present research, such processing experiences were elicited using various manipulations (e.g., varying the nature or appearance of the to-be-encoded items, varying the number of items to-be-retrieved from memory) and once evoked, participants attended to the information they provided to guide their judgments of elapsed time. Undoubtedly, these individuals perceived this experiential information to be highly relevant and informative by virtue that it occurred in the right place and at the right time to be implicated in the judgment.

Individual differences, however, could impact on whether the current manipulations of task difficulty are successful in eliciting these distinctive cognitive experiences in some people. Consider for example, the task of committing twenty low-frequency words to memory (Expt. 1). Although participants considered this encoding task to be difficult and demanding, this would surely not be the case for individuals who are capable of amazing feats of memory (i.e., memory experts). Such people would presumably use their expertise and engage in various mnemonic strategies to imbue these rare words with meaning by integrating them with pre-existing knowledge that already resides in memory. In a similar vein, the task of retrieving thirty-five animal names from memory (Expt. 6) proved to be a mentally demanding and effortful task for participants, but it is unlikely that zoo-keepers would experience the same difficulty. In both instances, attributes of the person (i.e., level of knowledge in the content domain) would cause the subjective experience of processing difficulty to be

absent. Thus, it becomes apparent that under such conditions, experiential effects on judgments of elapsed time would not have emerged among these individuals. This does not imply, however, that this should always happen. It is conceivable to assume that if the difficulty of the task was increased by having these individuals encode or retrieve a larger number of items, then they would also show experiential effects on their retrospective duration judgments. This is another possible route of investigation for future research.

The important lesson to take away from this is that the relative difficulty of an information processing task varies for different people and within different domains. For this reason, it is necessary to consider individual differences when choosing manipulations of task difficulty. Pretesting provides a useful avenue through which to establish what constitutes an easy or a difficult task for performers. If, however, the difficulty of the task is set at the appropriate level, then experiential effects on people's judgments of remembered duration should be remarkably robust and widespread. After all, we automatically assume that our subjective experiences are caused by whatever occupies our minds at the time and thus, it becomes extremely difficult not to use the information they provide when we consider the judgment at hand - in this instance, when we make an assessment of elapsed time. One exception, perhaps, is individuals who are particularly adept at estimating time periods in their recent past due to their vocations (e.g., time experts, athletes, shift-workers). The constant requirement to estimate time accurately might make such individuals less susceptible to these experiential effects. Future research should investigate this possibility, in addition to charting the generality of ease of processing effects across different samples of the general population (e.g., children, older adults).

6.5 FUTURE DIRECTIONS

Throughout this discussion, attention has been drawn to various issues that have arisen from the current research which warrant further investigation. However, some other issues will be considered here. Whilst the present results provide compelling evidence that people use the subjective ease or difficulty of prior processing operations (e.g., encoding, retrieval) as a cue to guide their retrospective duration judgments, this finding can only be generalised to objective clock time durations in the second and minute range. The shortest duration studied was 46 s and the longest

was 4 min 47 s. In daily life, however, people routinely make judgments of duration that run to seconds, minutes, and hours. The question remains, therefore, whether comparable effects would emerge for retrospective estimates of extended temporal episodes. At the present time, little is known about the cognitive processes that mediate people's assessments of elapsed time from about 6 minutes into the hour range (Block, 1989a; Zakay, 1990). Thus, it becomes apparent that if our understanding of retrospective timing is to increase further, this is a necessary route of exploration.

As well as investigating the extent to which experiences of ease or difficulty evoked by memory processing operations influence people's retrospective judgments of longer durations, future research should continue to determine the generality of these effects across different task contexts, manipulations of processing difficulty, and duration judgment methods. Another task for future work will be to determine the underlying processes and neural substrates of the judgments observed in the current research. At a more general level, the experiential concomitants of cognitive operations are likely to inform a variety of judgments in a wide range of domains. Future research should therefore continue to investigate the extent and boundary conditions of these powerful effects.

Finally, the results of the last experiment in this thesis highlight the utility of conducting retrospective temporal estimation research using immersive virtual environment technology (IVET). In trying to gain an understanding of the underlying processes of retrospective timing, researchers have stayed within the narrow confines of the laboratory. Whilst the activities that participants are required to perform in laboratory-based studies are representative of tasks encountered in everyday life, it is impossible in this setting to fully capture the range of events we experience and retrospectively estimate on a daily basis. IVET, however, provides a relatively new and exciting forum for researchers to create virtual environments that simulate the essential characteristics and richness of the real world in a controlled experimental setting. One can reasonably surmise from this that IVET holds great promise for experimental research on retrospective duration timing as people's time estimation abilities can be studied in a wide range of dynamic social situations. Researchers in this domain should therefore take advantage of the benefits that this powerful and

unique digital tool has to offer and no doubt theoretical advances into the problem of retrospective temporal estimation will follow.

6.6 CONCLUSIONS

In conclusion, the present research shows that the traditional memory-based models of retrospective duration estimation fail to fully capture the complexity involved when people make assessments of elapsed time. Although people undoubtedly use the contents of memory as a cue to guide their retrospective duration judgments in some time estimation situations, the current findings provide compelling evidence that this is not the only cue that people use. The consistent pattern of results obtained throughout this work convincingly demonstrates that people also derive informational input for their temporal judgments from their experiences of ease or difficulty evoked by memory processing operations. That is, individuals consider whether the informational content that fills the relevant interval was placed into the mind or brought to mind with ease or with difficulty. This conclusion is consistent with a large body of research in social cognition which has shown that subjective experiences that accompany information processing play an important and central role in determining people's judgmental outcomes in a wide range of domains. Thus, I can end this thesis with a powerful statement. To move forward in our understanding of the cognitive dynamics of human judgment and decision-making, the study of subjective experiential states must long continue.

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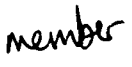
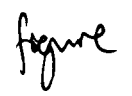
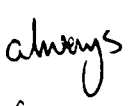
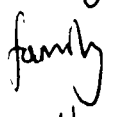
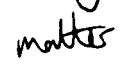
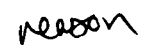
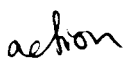
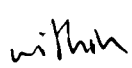
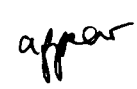
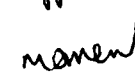
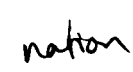
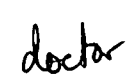
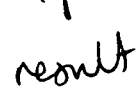
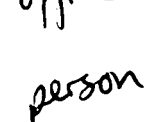
APPENDICES

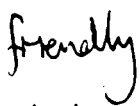
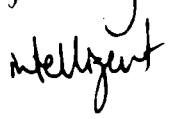
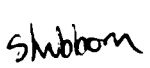
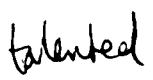
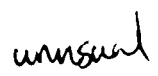
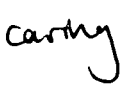
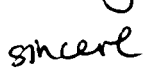
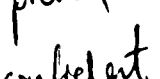
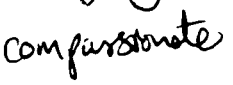
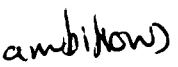
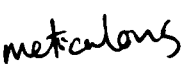
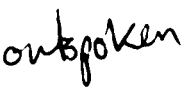
APPENDIX 1. Stimulus Words Used in Experiment 1

High-Frequency Words	Low-Frequency Words
number	accost
follow	confer
member	menace
before	debate
figure	tunnel
always	gossip
family	harass
matter	potent
reason	static
second	donate
action	script
within	purity
appear	elite
moment	quaint
nation	forego
doctor	domain
expect	lately
result	dispel
office	intent
person	impair

APPENDIX 2. Stimulus Words Used in Experiment 2

Typed Words	Handwritten Words
number	
follow	
member	
before	
figure	
always	
family	
matter	
reason	
second	
action	
within	
appear	
moment	
nation	
doctor	
expect	
result	
office	
person	

APPENDIX 3. Stimulus Words Used in Experiment 3

Typed Trait Words	Handwritten Trait Words
Mary is:	Mary is:
friendly	
intelligent	
stubborn	
helpful	
talented	
unusual	
caring	
sincere	
proud	
confident	
moody	
outgoing	
compassionate	
ambitious	
motivated	
meticulous	
outspoken	
loyal	
adventurous	
impatient	

APPENDIX 4.

Stimulus Passage Used in Experiment 4

As I had some spare time on my hands, I decided that it would be a great laugh to visit some of my friends who lived all over the country. So I packed my bags and left **Guildford** for a few weeks. My first port of call was **Staines**, where I'd arranged to meet up with my friend Laura. We both decided to go out on the town for a few drinks and a bite to eat. She suggested that the following day we should visit her mother in **St. Albans** as she'd spoil us with a slap-up home-cooked meal!

Having recharged our batteries with lots of home delicacies, we decided to take a trip to **Luton**, as we'd heard that the biggest indoor circus was being held there. We definitely weren't disappointed – the show was spectacular. The day was made even more worthwhile, when we accidentally bumped into another of our friends, Charlie. He invited us back to his house in **Ipswich** and said we could stay over for the night. The following morning, Laura travelled back to **Richmond** and after saying my goodbyes, I set off to **Cambridge** to see Fiona. We had a really relaxing day together watching the regatta on the river. It was a shame that I had to leave later that afternoon, as I'd already arranged to meet up with my Aunt and Uncle in **Peterborough** for an evening meal.

My cousin, Guy was planning to visit **Loughborough** the next day to have a look around the university there. He was trying to decide which university to study at after he'd finished his A-levels, so I decided to go with him. I didn't mind because it meant that I could visit **Leicester** at the same time. On our journey, I remember him telling me that he'd already visited the Universities of **Reading**, **Birmingham** and **Chester**, but he was keen to get a feel for all the universities he'd applied to. As he was really excited about the prospect of going to university, I kept him entertained by telling him lots of stories about my life in **St. Andrews** as a student. I explained how it was surrounded by many places that I'd never been to before, like **Dundee** and **Aberdeen** and being a student around there gave me the opportunity to explore all its nearby towns and cities. The conversation reminded me that I'd still like to visit **Inverness** and **Paisley**.

However for the time being, my plans were to visit my boyfriend. Paul in **Colwyn Bay**. I was going to stay with him for a few days before heading further north. That night, we went to see the latest James Bond movie in **Crewe** which we thoroughly enjoyed. The following day, we browsed round the shops in **Birkenhead**, quite near to **Liverpool** and stopped off at a casino there to try our luck. Then we returned back to Paul's house later that evening. I got up quite early the next morning because a big party had been organised by some of my friends in **Huddersfield**. It was great to catch up with them all and after the party, I accompanied Julie back to her house in **Bradford**. She was going to a big carnival in **Blackpool** the following day, so I stayed at hers so I could go along too.

Surprisingly, Julie asked if she could be my travelling companion for the rest of my tour around the UK, because she'd never been further north than **Harrogate** before. I loved this idea, so we set off to the old Roman town of **York** together. After discussing where we'd like to go next, we decided that the East Coast of England would be a scenic place to visit. We chose the seaside town of **Scarborough**, where we fished for crabs off the pier. **Whitby** was our next port of call. We climbed the 99 steps up to the castle giving us the most amazing view – we could see for miles around!

Having had so much sea-breeze fresh air, the road ahead took us to **Durham**, where the cathedral dominated the skyline. We spoilt ourselves by buying clothes, souvenirs and some presents for our friends. We couldn't leave the north-east without going to a football match with my favourite team, Newcastle United, so to **Newcastle** we went. To my delight, they beat **Middlesbrough** 2-1 giving them top place in the Premiership above **Southampton** who lost to **Bolton**.

Scotland bound, we drove to **Jedburgh**. We stayed in a quaint B&B and took the opportunity to explore the nearby National Park. After spending a few days walking, cycling and canoeing, a much needed rest was on the agenda. Fortunately, our friend, Ally only lived a short drive away in **Berwick-upon-Tweed**, so we packed our bags and set off in that direction. After living in the lap of luxury for a couple of days, our itchy feet wanted to travel again. Heading further northwards, this time to **North Berwick**, we were amazed by the beautiful scenery. I even managed a hole-in-one on the local golf course. In fact, the weather was so clear, we could see **Kirkcaldy** and

Dunfermline on the other side of the bay. This view was the perfect ending to my trip around Great Britain. All that remained for me to do was to drop Julie off and to head home myself. However, I decided to make one last stop in **Doncaster** to see my parents first, so I could tell them all about my great adventure and how it was an experience that I will never forget!

Distractor Items Used in the Recognition Test in Experiment 4

Ashford, Slough, St. Ives, Hertford, Harwich, Hounslow, Stevenage, Wellingborough, Gainsborough, Worcester, Oxford, Nottingham, Wrexham, Glenrothes, Perth, Edinburgh, Inveraray, Greenock, Llandudno, Leigh, Warrington, Manchester, Sheffield, Barnsley, Blackburn, Wetherby, Leeds, Knaresborough, Saltburn, Gateshead, Sunderland, Darlington, Winchester, Wigan, Alnwick, Cornhill-on-Tweed, East Linton, Kilmarnock, Dumbarton, Lancaster.

APPENDIX 5.

Stimulus Passage Used in Experiment 5

Pre-heat the oven to gas mark 5, 190°C (375°F). Slice a red **pepper** into long strips and chop 2 **onions** into small pieces. Put them in an ovenproof dish together with two crushed **garlic cloves**, then cover with 150ml (5fl oz) of **olive-oil**, two tablespoons of **red wine** and a pinch of **sugar**. Bake for 40 minutes or until slightly coloured.

Cut 1 **courgette** into 2cm slices and do the same with 1 small **aubergine**. Then chop 2 small **carrots** and 2 **leeks** into thick slices. Also, shred half a Savoy **cabbage** and divide a **cauliflower** into small florets. Trim 1 small **fennel** bulb and cut into 4 pieces lengthways. Place all the ingredients in an ovenproof dish with 1 tablespoon of **lemon juice**, 2 tablespoons of **double cream** and 50g (2oz) of finely chopped **walnut** pieces. Season generously with fresh **coriander**, **cayenne pepper** and half a teaspoon of dried **oregano**. Mix well and bake for 30 minutes or until tender. Then remove from the heat and leave to cool.

Peel and dice 2 large **potatoes** and plunge them into a large pan of water with a few fresh **mint** leaves. Cook for 12-15 minutes or until soft when pierced with the point of a sharp knife. Meanwhile, cut a **lamb** neck fillet into small cubes. Place 150g (5oz) of **plain flour**, 4 **egg-yolks** and 1 teaspoon of **milk** in a food processor and process for 1 minute until the mixture resembles fine **breadcrumbs**. Toss the meat in 1 dessertspoon of **paprika** and 1 tablespoon of chopped fresh **sage**. Then cover each piece in the mixture from the food processor. Then place them in a heavy-based pan and fry until lightly browned.

Stir 1 dessertspoon each of chopped fresh **basil**, **tarragon**, **thyme** and **rosemary** into the mixture which was prepared first. Season generously and marinate for up to 2 hours. Melt the **butter** in a frying pan and cook 4 sliced **mushrooms**, 25g (1oz) of black **olives** and some baby **tomatoes** over a high heat for 2-3 minutes. Divide 1 small cooked **beetroot** and 1 heaped teaspoon of **sultanas** between 2 serving plates. Then put all the other ingredients on the two plates and sprinkle with 1 tablespoon of chopped fresh **parsley**. Serve at room temperature with some crusty **bread** if preferred.

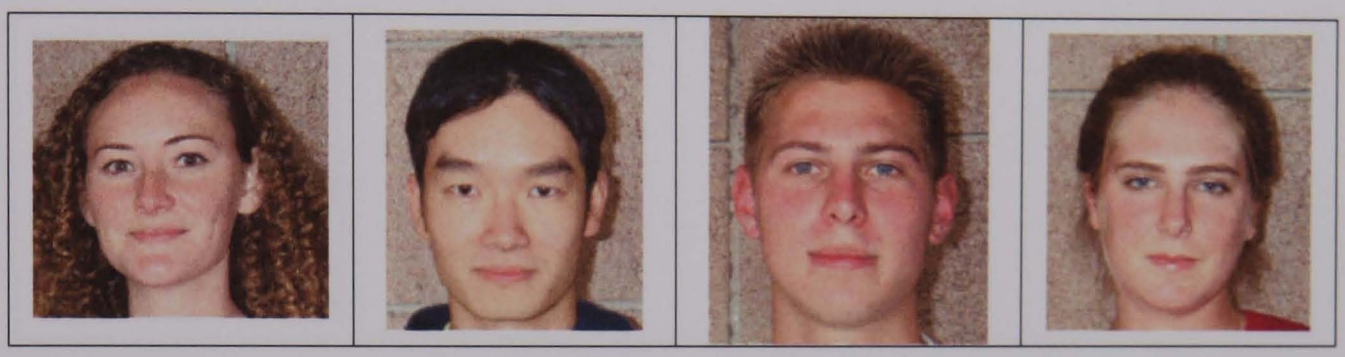
Distractor Items Used in the Recognition Test in Experiment 5

Chilli, turnips, root ginger, sunflower oil, white wine, honey, marrow, artichoke, parsnips, peas, spinach, asparagus, nutmeg, lime juice, single cream, almonds, cinnamon, chilli powder, vanilla, broccoli, chives, pork, self-raising flour, egg-whites, cheese, croutons, cardamom, dill, chervil, turmeric, bay, marjoram, margarine, pumpkin, capers, celery, sweetcorn, raisins, cumin, rice.

APPENDIX 6. Stimulus Faces Used in Experiment 9

Visual Noise Absent

1 2 3 4



5 6 7 8

9 10 11 12

13 14 15 16

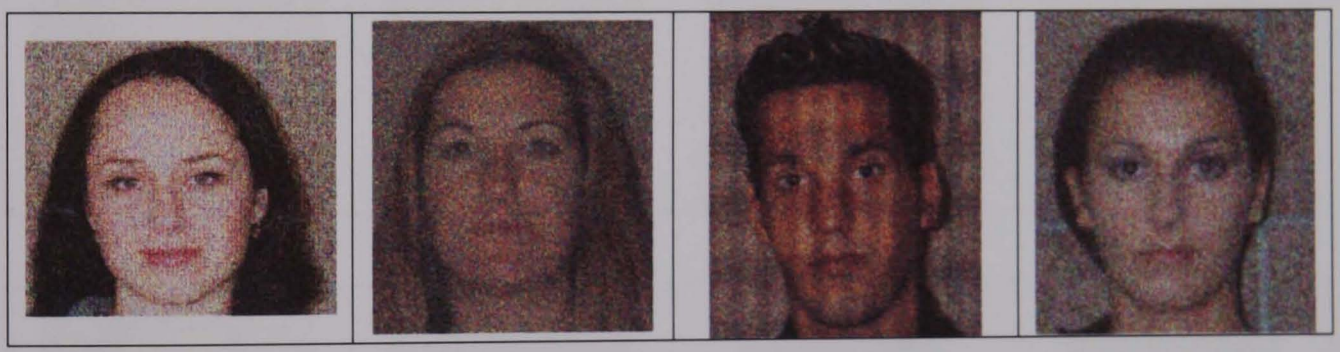
17 18 19 20

APPENDIX 7. Stimulus Faces Used in Experiment 9

Visual Noise Present

1 2 3 4

5 6 7 8



9 10 11 12

13 14 15 16

17 18 19 20

APPENDIX 8. Distractor Faces Used in the Recognition Test in Experiment 9